

Evaluating health information systems: An assessment of frameworks

ROHAN JAYASURIYA

Rohan Jayasuriya is Senior Lecturer, Department of Public Health and Nutrition, University of Wollongong.

Abstract

The rapid increase in investments for computerised systems is a major concern for all health organisations. Questions about these investments arise as information technology is only one of the areas that are competing for a finite amount of resources. There is also some concern that some of the failures of information technology would have been detected if proper evaluation of information systems were conducted. The state of the art of evaluating information systems shows changes from a very positivist approach to more comprehensive approaches that would incorporate multiple methods. This paper presents an assessment of the techniques and methods for information systems evaluation, followed by an application to a case study in community health to illustrate the value of the contextualist approach to evaluation. The paper argues for the use of longitudinal, contextualist approaches to information systems evaluation if decision-makers seek to improve the situation of information systems in the health industry.

Introduction

Information technology (IT) has had a wide impact on the work of organisations worldwide. Its impact has also been considerable on the health sector and is related to the following.

1. *The increasing use of IT to support the core business of the organisation.* This is typified by the use of IT in hospitals for laboratory systems, systems to manage admission and discharge and inventory. Currently these systems depend heavily on IT as most systems of information are now fully computerised.

2. *The transformation of the way clinical work is done.* The use of computerised care planning and computerised medical records is increasingly changing the manner in which professionals in the health sector carry out their day-to-day work.
3. *The increasing complexity of information systems as health organisations link with the external environment using IT to make the communication links.* This also results in data standards and database design becoming increasingly important, as well as complex.

In this paper, information systems are used as a wider concept than IT to refer to how designed information collections and flows meet the defined information requirements of the organisation (Willcocks & Lester 1993).

In the wider environment of business, it has been identified that the evaluation of costs and benefits of information systems is currently a major concern for senior general managers and that many organisations report that they are uncertain of methods to measure the impact of their IT investments (Farbey, Land & Targett 1992).

Evaluation services a number of objectives in the information system field. Howgood and Land (1988) identified the following objectives.

1. *To establish the feasibility of a new project.* The emphasis of these studies is to test economic, technical and organisational feasibility.
2. *To make organisational investment decisions.* There is competition for resources in all organisations and information systems also need to be subject to the same process. The problem in this case is whether the usual methods of evaluation used for investment decisions which are based mostly on accounting methods are sufficient. Farbey, Land & Targett (1993, p 9) state that due to the experience of using return on investment in judging investment decisions for IT projects, there is a quest for a 'one best' method. This has led to frustration as the characteristics of an information system project and its organisational environment affect these decisions.
3. *To review progress of information system projects.* Here the evaluation plays the role of project control. Typically, the planned changes in information systems are only part of the changes in the organisation and therefore major problems of information system implementation have been identified.
4. *To assess the impact of an information system on the organisation.* This is an area where much effort has been taken to identify common tools that could be used to compare information system projects in various environments. This may be the reason why there is insufficient consensus, as, for instance, the impact on a clinician will be quite different from that on a nurse unit manager.

5. *To assess value added by the information system function as a service providing department.* This is another area that is increasingly being given attention, especially with moves in organisations to have charge back systems, cost centre budgeting and outsourcing of the IT function.

However, in the United Kingdom it has been found that, in some cases, the greater the expense and strategic importance of an information system, the less likely it is to be evaluated using a formal methodology. This apparent paradox is attributed to the conceptual and operational problems of evaluating (Symons 1990).

Dowling (1980) found in a survey of hospitals that 45 per cent of information systems failed because of user resistance and staff interference, not system issues. Lyytinen (1987) reports similar failure rates in information systems in general. Often systems fail because developers concentrate on the technological aspects and neglect the social and political aspects (Lyytinen 1987; Kling & Scacchi 1982).

In a review of hospital information systems evaluation, Glandon and Shapiro (1988) identified a number of barriers to evaluation. They state that the first barrier is the acceptance of technology for technology sake and that some hospitals introduced systems just to keep up with the Joneses, the cost being no object. The second barrier is the constraints in methodology of cost-benefit and cost-effectiveness analysis where information systems contain many impacts that are difficult to measure and even more difficult to value monetarily. The other barrier they identified pertains to the issue that initial cost-benefit analysis projections are lost in the flurry of activity that accompanies systems implementation and managers consider this 'water under the bridge' when they need to evaluate it.

The question may be posed: Why do information systems need to be evaluated? There are many reasons. In the context of health information systems these are as follows.

1. *Economic efficiency*, where there are a number of recent trends that are disturbing.

Firstly, the investment in information systems is high in the health sector and is increasing. New South Wales Health has an \$800 million strategy for IT over 10 years (Crawford 1992). The Queensland Health Department has invested \$100 million for a new hospital information system (Fitzpatrick 1992). Questions about these investments arise as IT is only one of the areas competing for a finite amount of resources. There has been some concern that some of the failures of IT would have been detected if proper evaluations were conducted.

2. *Clinical effectiveness.* The use of IT in the diagnosis and management of patient care is increasing. In some areas the increases in effectiveness are not known. The investments of time and resources for clinicians to adapt to the new IT technology are a cause for concern. When changes in the use of these patient management systems take place, clinicians and managers need information to decide whether the change improves the health outcomes of the patients.

As the needs of information systems in the health sector grow, but resources are less freely available, it is only rational that managers will require assessments of effectiveness in order to fund new systems (Zviran 1992). In the current climate of cost consciousness in health care in Australia and worldwide, it is only a matter of time until organisations will be required to not only justify expenditure on information systems but demonstrate its impact on clinical effectiveness and health outcomes.

This paper will review the evolution of the art of information system evaluation, with a focus on identifying the major conceptual and operational frameworks. It will use a case study from the health sector to illustrate key issues faced in reality and assess the relevance of frameworks for evaluation of information systems in the health sector.

Evolution of the art of information systems evaluation

In the early 1980s, most of the work in information systems related to evaluating management information was treated as an integral part of the management control process (Hamilton & Chervany 1981). The main thrust of evaluation was to assess the effectiveness of the management information system. Two general approaches to measure IT were a goal-centred view and a systems resource-view. The former focused on the costs and benefits of the IT function and the latter on the process or functional aspects of the system. The distinction between the two has been described as being similar to the difference between summative and formative evaluation from the program evaluation literature (Hamilton & Chervany 1981). Management information system evaluation approaches identified by Hamilton and Chervany (1981) were broadly divided into efficiency-oriented and effectiveness-oriented and are presented in Table 1.

Information systems can be looked at from two perspectives: the computer systems domain and the user domain (Chandler 1982). Multiple perspectives dominated information system evaluation research in the 1980s. In approaching information systems with a view to their impact on organisational change, Eason

(1989) identified four dimensions of evaluation (see Table 1). The first, a technical systems performance which pertains to reliability and efficiency of the system. Typically, this is measured by system response time, downtime, recovery time, and so on. A second dimension was based on the functionality and useability of computer systems. This was measured by components such as task match, ease of use and ease of learning. A third dimension captured user performance and satisfaction. Many technical systems are designed to improve the task performance. Therefore, its evaluation must measure its impact on overall task performance. The final dimension he suggests is the need for evaluating the socio-technical systems performance and its ramifications as the introduction of new technology leads to changes in the socio-technical system.

Much of the development of measurement tools for information system evaluation in the late 1980s was related to the use of user satisfaction as a surrogate of the impact of the information system. Remenyi, Money & Twite (1993) review the extensive literature on this topic. These techniques incorporate user perceptions as a means of measuring the intangible benefits of information systems. By including user perceptions of the system performance, quality of service, quality of documentation, management involvement and user participation, instruments have been developed and tested for their psychometric properties to represent an holistic framework that can be used to measure effectiveness.

Often a system's life cycle has been used to identify the stages for evaluating an information system project during its development and implementation. Farbey, Land & Targett (1993) identify the following main stages.

1. Information system strategy development stage, where it is assessed against the business strategy.
2. Cost justification of the project.
3. In the development stage, to ensure that external changes have not affected it.
4. Point of 'sign off', when the system is transferred from the IT department to the user department.
5. Project implementation, to ensure that it is working as planned.
6. When it has been operational for some time, to assess its impact and to find out whether the actual costs and benefits are similar to planned costs and benefits.
7. End of life of the system, to assess for replacement options.

However, a survey of United Kingdom firms found that very few had conducted an ex ante or ex post evaluation. About half had used 'back stairs' methods to

Table 1: Frameworks for evaluating information systems

Management information system evaluation approaches	Dimensions of evaluation	Evaluation methods and approaches
<i>Hamilton & Chervany 1981</i>	<i>Eason 1989</i>	<i>Farbey, Land & Targett 1993</i>
Efficiency-oriented		Quantification methods
Quality assurance review	Technical systems performance	Cost/revenue analysis
Compliance audit review		Return on investment
Budget performance review	User evaluation of technical system	Cost-benefit analysis
Management information system personnel productivity measurement		Return on management
Computer performance evaluation	User performance and satisfaction	Boundary values
Post installation review		Information economics
Effectiveness-oriented		Exploratory and experimental techniques
Service level monitoring	Socio-technical systems performance	Multi-objective, multi-criteria methods
User attitude survey		Value analysis
Cost-benefit analysis		Critical success factors
		Experimental methods

affect decisions (Farbey, Land & Targett 1992). A common stage at which evaluation is conducted is the post-implementation review, typically done after the system has been implemented for some time. In a study of post-implementation evaluation of computer-based information systems in business organisations, the picture that emerged was much different to that espoused in the normative literature. The post-implementation review was used mostly as a 'close-out' device before or just after the system was handed over to the users. It was typically done by the system's development team and used as a major tactic for project disengagement. The study identified that superficial importance was given to the agreements on evaluation criteria and methods and the most frequently used criteria were related to information quality (accuracy, timeliness, adequacy and appropriateness). Systems impact was less frequently evaluated. They also highlighted their concern that 'it is unlikely that an evaluation managed and performed by the development team will discover any basic flaws in the process or the product design' (Kumar 1990, p 210).

An approach to match evaluation methods with that of IT investment was carried out by Farbey, Land & Targett (1993, p 142). They list a number of evaluation techniques available (see Table 1). A survey of 16 IT projects in the United Kingdom found that only nine were justified and that an ad hoc method was most commonly used (stating that the present system was obsolete and needed to be improved). Of the identified methods used, return on investment was used in three projects and cost-benefit in one. The authors state that an 'organisation wishing to sharpen its IT investments decision-making must first recognise that there are evaluation techniques other than return on investment' (Farbey, Land & Targett 1992, p 116).

These positivist approaches to information system evaluation have been challenged on the grounds that information systems cannot be treated as objective and rational (Hirscheim & Smithson 1988) and that the difficulty in using a positivist approach is the multidimensionality of cause and effect and the multiple and often different perspectives depending on the evaluators (Symons & Walsham 1988). The arguments have been based on the complexity of the connections to the context as expounded in the 'web model' (Kling & Scacchi 1982) and the contingency approach to evaluation (Legge 1984). The basic tenet of the web model is that a computer system is best conceptualised as an ensemble of equipment, application and techniques rather than as discrete entities. The model also incorporates the social and economic context by identifying that the infrastructure is embedded in a larger matrix of relations ('macrostructures'). According to the web model, the macrostructures and infrastructure direct the kind of computer-based services available, and themselves evolve over time. Thus

the web models are described as complex social objects constrained by their context, infrastructure and history (Kling & Sacchi 1982). Hirscheim and Smithson (1988) also state that the use of analytic frameworks are not suitable as information systems cannot be viewed in isolation from the complex social and political environments in which they are embedded. Symons and Walsham (1988, p 122) believe that 'positivist designs which seek to shield the causal process of a study...render unreal any inferences drawn from their evaluation'.

These interpretivist views consider the overt and covert functions of an evaluation and recognise that the evaluation cannot be separate from the study. They state that in an evaluation design the questions and data collected are selected on assumptions that are value-laden (Symons & Walsham 1988). Evaluation of information systems has been identified as a political process depending on the interests of the stakeholders (Avgerou 1995). Others have emphasised the political issues related to evaluation to explain the social actions of players (Sauer 1993). These social scientists have emphasised that evaluation is a social process and that they 'view evaluation not as an approach of a set of tools and techniques, but as a process to be understood' (Symons & Walsham 1988, p 123).

Over the years, information system evaluation has been informed and has imbibed principles and concepts from both the evaluation research and organisational change literature. The relationship between evaluation of information systems and organisational change has been emphasised (Avgerou 1995). Based on the contextualist approach to research that was used to study organisational change, the content of evaluation is considered as separate from the context and process. Contextualists consider two levels of analysis (the outer and inner context) and require time series, processual data to understand the factors through any particular sequence of events and action (Pettigrew 1985). Five problem areas in evaluation research have been identified in social program evaluation (Rossi & Williams 1972). Farbey, Land & Targett (1993) have taken concepts from these fields to develop a framework for issues in IT evaluation. They added the concept of 'organisational learning' in the process dimension to show that the evaluation itself presents an opportunity for organisational learning and communication. Figure 1 shows a simple adaptation of their framework.

Contextualist approach	Problems in social evaluation
1. Content	Conceptual problems Methodological problems
2. Process	Organisational Learning
3. Context	Bureaucratic problems Political problems Organisational problems

Source: Adapted from Farbey, Land & Targett 1993

Figure 1: Issues in information system evaluation

Avgerou (1995) suggests an alternative approach to information system evaluation, based on the work of Guba and Lincoln (1989) from the general evaluation literature. The emphasis in this case is on the need for the criteria for evaluation to emerge from the concerns and consensus achieved with stakeholders. This fits with the concepts of organisational learning that occurs in the process of evaluation. At a practical and operational level, it is suggested that the evaluation process provides tools to encourage communication between stakeholders and promote organisational learning (Serafeimidis & Smithson 1996).

In summary, the review of the evolution of information system evaluation shows a trend to expand the dimensions to incorporate concepts and methods from the organisational change and general evaluation literature. The value of this approach will be illustrated by using a case study in the health sector.

Case study: Evaluation of a computerised information system for community health

This system was designed in-house by a health professional on a micro-computer platform over three years (1992–1994) in an area health service in New South Wales. The objective of the system was to capture information about the use of community health resources. The impetus for the development was a review of the community health services which recognised inadequacies in the manual system of information such as:

- data were not comparable between services
- no data were available on current clients

- staff lacked commitment to any data system
- an over emphasis on numbers rather than outcomes
- collected data not being used by community health staff generally.

The plan was to establish an appropriate data set and then develop a software package (which for the purposes of the case study will be called COMIS) to manage it. The developer spent time consulting both clinical and administrative staff to decide on the data items, its collection and processing methods. As the users lacked computer experience, the developer spent much time developing prototypes that were tested at a pilot site. Each of the health centres was to have standalone PCs for this system and eventually a data link was to be established to a central computer through modems. Along with developing systems, the developer had to negotiate for resources (hardware) for the centres and staff to maintain the system. A formal feasibility study had not been undertaken at the commencement of the project and it was not clear who was responsible for the project. The system took longer than scheduled to be operational for many of these reasons and there were questions about its efficacy and its future.

The evaluation was conceived as an 'action research' project in the stage when the early prototypes were being developed. The evaluator therefore was able to participate in the development phase and, as he was external to the organisation, continue to have an independent opinion. The methodology used for the evaluation followed a formal-rational perspective and was based on the framework of Eason(1989) and concentrated on user evaluation of system performance and user performance and satisfaction (Jayasuriya, Foulstone & Little 1993). The following techniques were used.

1. Measurement of user satisfaction. An instrument was developed by adapting Doll and Torkzadeh's (1988) end-user satisfaction instrument, following a focus group to identify user perceptions of attributes of an effective information system.
2. A measure of information system problem resolution by the new computerised information system using a gap analysis approach (Remenyi, Money & Twite 1993).

The use of quantitative measurement of user satisfaction showed that the content was satisfactory for most but did not give a real picture of their work for 57 per cent of the respondents. The format of the information was found to be meaningful and clear for 61 per cent and 81 per cent respectively. Of those who accessed the system, all found it easy to use. However, 71 per cent said that the system was slow in operation. The main findings of these assessments were that

the content of information and format were satisfactory. The system was user-friendly and easy to use. However, the training was insufficient and the system was slow in operation.

A positivist approach to evaluation is illustrated in the above case where the concentration was on the content areas such as the measurement of user satisfaction (as a proxy for system success) and user evaluation of system performance. Some interviews were also conducted to ascertain the success of project management.

However, using the framework of the contextualist approach requires that the evaluation also covers the process and context components. The context can be analysed at two levels: the inner context which refers to the intra-organisational issues and the outer context that covers the extra-organisational and environmental issues (Pettigrew 1985).

The methods used to carry out the contextualist analysis of retrospective change were based on a variety of data sources. Archival documentation of the system was carried out. One of the evaluators participated in steering committee meetings to get a feel for the issues and to become sensitised to the 'real' issues. The evaluators also conducted some in-depth interviews with two managers to collect qualitative data on the impact of the system. A focus group with seven users was conducted to obtain their views of 'success' of the system. In all, the evaluators participated in the work in the field over a period of about one year. These investigations, together with interviews with the developer, were then content analysed to provide material on the context of the case. Based on the model of Figure 1, the classification of bureaucratic, political and organisational issues will be used to present the relevant findings from the contextualist analysis.

Bureaucratic

The project did not go through a formal feasibility study and approval. Therefore, there was no ownership by the users (community health centre staff) nor the IT services of the organisation. The developer was from another unit in the organisation which had been given the responsibility to proceed. This created problems as the developer was not from the IT services and bureaucracy demanded that all software and hardware acquisitions be made through the IT services. As an approved budget was not available, hardware was acquired on an ad hoc basis. When computers were given to the units, there was pressure to use them for other clerical work rather than for the COMIS system. The project developer did not have formal authority on these issues, which led to many conflicts and delays in implementation.

At the start, the State Department of Health mandated the use of one particular type of software for PCs that was later not supported. The developer therefore ended up having to find support from the vendors by himself. If a choice was available at the start for the developer, this may not have occurred.

Political

A steering committee was formed to coordinate the development. This committee was disbanded subsequently as the developer found that it created obstacles to development rather than facilitating development. This arose partly from the disagreement between the developer and the chairperson. An underlying factor was that the managerial staff who comprised the steering committee saw the system as a tool to manage (more explicitly 'control') staff. This was very obvious in the qualitative findings.

...as a manager, I need to know something about the services that we are providing.

I need to know in a general sense, what proportion of time of a drug and alcohol worker's time is taken for drug and alcohol work as opposed to other work.

...I suppose, eventually...to link our activities through our staffing levels and our budget information.

...to make sense of it, we have to get more details on non-client-related activities.

This made sense from the perspective of a manager. However, the developer disagreed because past experience had proved that clinicians would deliberately enter false information if they were aware that the data collection was to oversee how they utilised their time. There was also resistance on the part of the specialist consultants who felt that the system could not capture the complex activities they performed as the system reduced their activities into a few codes. This simplified coding system made them feel that they lost their technical power.

Organisational

In organisational terms, the development occurred during a transition period where the area health service was undergoing an organisational overhaul. The resultant insecurity of office and threats of mergers of managerial sectors and so on did not create a positive environment for new developments.

The impact of the system was also sought in the more qualitative data gathering exercises. The findings show that the perspective of the impact related to the position of the respondent. Respondents at a level close to the field staff showed some enthusiasm for its benefits.

...they are quite happy and quite willing to implement a new process as long as it proves beneficial to them in the long run...

...since the computer has come in...a computer has a memory, so if you saw someone 3 or 4 years ago...you can recall it.

I think it is a lot quicker for clients to be registered on the computer than it was to do it manually.

I think that the computer is like an extra telex...I think it is just an extra additive.

For respondents (managers) at a distance it meant:

...but generally, clinically oriented staff aren't keen on data collection systems, half of them despise computers.

I am not as convinced as X (the developer) that people are actually going to use it as often as he would like.

...there are a few people down there on those levels that have some interest but mostly we see data systems of any sort as just a imposition, something we have to do but only if we can't avoid it.

The main concern of staff related to the change involved.

In the past 17 years we have probably had about 15 or 20 different methods of collecting information...people do get quite stressed at having the changes.

...the frustration of changing from one system, collecting information and another, and another...

I think we have to be prepared to change it when we have tried it out and not just stick with something because it is internally consistent, or it looks nice, or it works well with the computer.

Epilogue to the case study

The community health information system was implemented over the next year in all the sites and most of the data collection mechanisms were put into place. Following a resurgence of interest in community health issues by the State health department, funding was identified to develop a statewide system. Further investments at the local level (area health service) were stopped in view of these

developments. There is still some concern about the use of the information but the developments allowed the community health services to undergo a 'learning' phase. This experience has enabled the managers to have a positive attitude towards future developments. However, many of the clinical staff did not use the system except for some administrative tasks and this provided the feedback on the necessity to have systems that provide value to clinical staff if the systems are to be used.

Due to the turbulent nature of the environment and the non-involvement of the IT services in the original development, significant 'learning' of the process of IT development did not occur. As there was no 'champion' or 'business sponsor', an organisational commitment was not seen and the development died when a new community health manager was appointed. The promise of a statewide system also influenced the decision of the new manager as well as the stringent budget for the services.

Discussion

The above case study illustrates the gains that can be made in using multiple methods of evaluation and the conduct of longitudinal studies. Unfortunately, most often information system evaluations are contracted out as one-off studies. The framework of Farbey, Land and Targett (1993) is a useful tool to identify the issues that have to be incorporated in an evaluation of information systems in organisations. This case study illustrates that the assessment based on a contextualist approach provides a richer picture of the information system, its outputs and impact on the organisation. It provides an explanation for the intended (planned) and the unintended (unplanned) effects that occurred. As Pettigrew (1985) argues, the context examines the organisational background in terms of who is involved and why.

Positivist approaches and the use of techniques that seek to ascertain an objective measure of success only address the content area of the framework. If only the assessment of content was used, the quantitative findings showed that the content was satisfactory and the format was meaningful and clear for the majority of respondents. The issues of the relative lack of use by clinicians and why the developments ceased cannot be explained without the contextual information. The case study also shows that there is a need to value the evaluation process as an 'organisational learning' process. In the normative literature of program evaluation, this is termed 'formative evaluation' (Rossi & Freeman 1985). The participating organisations need to be visited for observations regularly, with the view to reflecting on the decision-making activities that take place in the lifetime of an information system.

Another aspect that is important in information system evaluation is the need to maintain the independence from the development to be able to make an unbiased assessment. However, most post-implementation reviews are carried out by 'insiders'. Sometimes they are used as mechanisms to obtain support of decision-makers to address recommendations that pertain mostly to implementation issues (Kelly 1996). The limitation of the one-time post-implementation review approach is that it concentrates on efforts to produce a 'close-out' report (Kumar 1990). The systems impact is therefore not given the consideration it deserves. Information systems are a unique combination of technically complex components embedded in human interaction. Practitioners are able to identify the extent to which impacts are not achieved due to non-technical or political reasons. To elicit such information, qualitative approaches to evaluation need to be used. Borrowing from the organisational change literature, the contextualist approach therefore provides a framework for this to be carried out (Serafeimidis & Smithson 1996). In moving from a systems approach to change, this perspective allows one to explain the dynamic processes that happen with change. The content, context and process of change are central to this approach and longitudinal qualitative methods are needed to capture the data (Pettigrew 1985).

The health industry is an environment with increasing pressure for accountability of investments in IT and frequent failure of large IT projects. This trend will require multiple evaluations for information system projects. Evaluation can also play a central role in the process of organisational change in introducing information systems if the evaluation is carried out as a longitudinal process that facilitates communication and consultation to obtain the commitment of the interest groups. This paper has assessed frameworks that have been proposed by various authors and, based on the experience of a case study, argues for the value of using a longitudinal, contextualist approach to evaluation if decision-makers seek to improve information systems in the health industry.

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