Beyond effectiveness: the evaluation of information systems using a comprehensive health technology assessment framework

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Abstract

A Comprehensive Health Technology Assessment Framework is presented as a conceptual tool for decision-making about health technologies, including information technologies. The aim of the model is to provide an empirical, evidence-based foundation for health technology decisions. The major framework dimensions are (1) population at risk, (2) population impact, (3) economic concerns, (4) social context (including ethical, legal, and political concerns), and (5) technology assessment information. This multi-disciplinary approach provides guidelines on use of appropriate information in aligning ‘stakeholder wants’ and ‘population needs’. © 2002 Elsevier Science Ltd. All rights reserved.

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1. Introduction and purpose

Decision-making in health care is increasingly expected to be transparent and accountable. The decision process itself should also be clear and explicit, since otherwise it is unlikely to produce consistent conclusions. Health care administrators consequently need the kind of high-quality information that supports rational and defensible policy choices. Yet decisions on the adoption of emerging health care technologies are often made in the absence of comprehensive (or even general) information about important implications of their use.
Several problems can be identified. First, decision-makers may quite simply not be aware of what information they lack. A related difficulty is that individual decision-makers tend, perhaps inevitably, towards a restricted viewpoint which generally identifies only part of the potential impact of a given technology. They are also apt to respond to situations as they interpret them, rather than objectively; and even when objectivity is seen as a priority, the same problem addressed in different frames can produce entirely dissimilar responses.

Furthermore, decision-making usually involves some kind of trade-off. Most people adopt a simple decision-making rule that trading-off must be between resources assumed to be commensurate. If resources are wrongly seen as commensurate or, more usually, not identified as commensurate, unforeseen consequences may result, or opportunities lost. Finally, policy-makers rarely get adequate feedback on the broad consequences of their decisions [1].

Ideally, health technology decisions should be based on evidence from comprehensive assessment; that is, information about effectiveness, costs, and the relevant ethical, legal, and social implications. Health technology assessment (HTA) is the systematic evaluation and synthesis of evidence on the properties, effects, and other impacts of health technologies. While the field of technology assessment is a relatively new one (and still engaged with some thorny developmental problems arising from co-ordination of multi-disciplinary work), it has begun to construct some powerful tools with capacity to synthesize diverse data sets. Research indicates, however, that the usefulness of HTA-generated scientific evidence is likely to be limited if its development is divorced from decision-making processes.

The value of integrating technology assessment research with public policy was recognized more than two decades ago [2]. It was proposed that the research process should include a means of engaging with the values that form part of the bureaucratic–political environment [3]. Regardless of disciplinary perspective, researchers generally agree that political considerations constitute an important dimension of technology assessment [4,5].

This paper presents a Comprehensive Health Technology Assessment Framework as a tool for well-informed decision-making in the ‘real world’. The purpose of the Framework is to provide an empirical, evidence-based foundation for health technology decisions, and to demystify the process which has consistently been poorly understood, ill-defined, and ad hoc.

A particular focus is on application of the Comprehensive Framework to information systems evaluation. Under the broad definition of the US Institute of Medicine, health information systems can be classified as health technologies, which—together with devices, drugs, and medical or surgical procedures—include the ‘organizational/administrative and support systems within which health care is delivered’ [6].

While differing from clinical interventions in important ways, health information systems can be envisaged as having a significant potential to affect patient outcomes. For example, a telehealth application offering rapid consultation for populations with restricted access to diagnostic or specialist services may enable earlier or more accurate diagnosis; more effective clinical management decisions; and ultimately better patient outcomes. In addition, telehealth may provide the kind of professional support that practitioners in isolated regions need, and may perhaps contribute to better distribution of health practitioners. The best, indeed the only way to determine if these anticipated benefits are being realized (or perhaps undermined) is through comprehensive evaluation.

The conceptual model of the Framework can be applied within varied contexts. In publicly insured health care systems, and to a considerable extent in mixed and even private systems, governments
play an influential role in the development and diffusion of technology. This role spans many levels of involvement, including support for development of technologies through funding basic sciences research, regulating the marketing of certain technologies, licensing facilities for service provision, and paying for services through public funds. Given this wide range of responsibility amid a bewildering array of choices, the most important issue for decision-makers is how to simplify the complexities.

Decision support models are able to clarify the process of thinking about and evaluating alternatives, and to make the available choices and their consequences transparent to the decision-maker. While most decisions do not follow an explicit stage-by-stage process, implicit rules of decision-making can nevertheless be seen to operate. In fact, the literature in decision research indicates that, in making important decisions, general, formal, or complex rules of decision-making are usually desirable. Furthermore, an admix of general and specific, simple and complex rules give the best results, that is, better decisions [7].

The Comprehensive Health Technology Assessment Framework meets these criteria. It incorporates three questions essential to this type of explicit decision-making process:

(i) Who?
(ii) What for?
(iii) How much and for whom?

1.1. Who?—the stakeholders

Who?
- Who is (or should be) involved in decisions on health technology adoption?
- Who is affected by those decisions? Who are the special interest groups? Who has control of resources affecting development and adoption of the technology?

These questions identify the people influencing the decision to adopt a new technology, and the people who will be influenced by it.

The major players in a complex system such as health care include many special interest groups or ‘stakeholders’. The different players have natural allegiance to their own groups or organizations, and may hold partisan views of the desired outcome which differ from those of other groups having an interest in a decision. This is not necessarily intentional bias, but is more likely attributable to loyalty to the constituency and to lack of knowledge about the broader perspective, or of capacity to incorporate it. In short, individuals function within social contexts and cannot be expected to hold objective views about technology.

We may therefore find that at the individual level, the practitioner is most motivated by clinical efficacy; the administrator by fiscal and other resource implications having an impact on quality of care; the government agency by budgetary restrictions (economic efficiency); and the client or recipient of the new technology by safety concerns. Each is likely to operate within what might be considered proper or ‘ethical’ behaviour, based on principles of ethical individualism which are deeply rooted in North American culture [8].
If a decision is to be regarded as acceptable, therefore, the process leading to it has to be seen as fair. The first condition for a fair process is that all stakeholders likely to have an interest in the new technology (producers, users, recipients, and payers) should agree on, and have a role in, the decision-making process. The fundamental question to ask at this stage is: ‘Who is, or should be, involved in decisions about the adoption of new health technology?’

A skilled approach to the question would avoid limiting the answer to the ‘traditional’ players in the system—those who can influence the decision—but would seek to identify those likely to be influenced or affected by the decision to adopt new technology. Fig. 1 depicts the initial steps of a systematic process that, at the time a new technology is emerging, seeks to determine all the players and to select representatives who should constitute the decision-making body.

For a decision on the adoption of a telehealth system, for example, the following stakeholders can be identified as influencing and being influenced by the use of the technology:

- **patients** have an interest in increased access to care, but also require assurance that health outcomes, if not increased, are at least not worsened;
- **providers** have an interest in how telehealth services will be re-imbursted, as well as in clinical efficacy;
- **third-party payers** will want to know the impact of a technology and its related system on resource use, as well as the implications for their accountability structures. There may, for example, be new staffing or training requirements affecting administrative or support staff;
- **technology producers** aim to enhance the market-share for their products.

Other more broadly based stakeholder groups with an interest in telehealth systems would include communities, organizations, institutions, and systems. For example, linking a geographically remote community may have implications for local politicians. The local health care delivery system may be affected, irrevocably altering inter-provider relationships. Changes may be needed in the regulatory framework. And information system development and support may need to accommodate particular telehealth requirements.

Current practice of those involved in decisions on health technology adoption frequently encourages some of the most influential players to lobby in support of their ‘cause’. As technology assessment and decision-making become better co-ordinated at the system level, attention should be paid to eliminating structural barriers, usually through the clarification of long-standing ambiguities regarding decision-making authority among government levels. The attenuation of chronic border disputes between government and medicine, or between government and hospitals, over who decides what issues, should in particular clarify who is the target audience for information generated through technology assessment [9].

Owing to its systematic approach, the process defined by the Comprehensive Health Technology Assessment Framework can expose the political or social power of those who make key decisions during the development and diffusion of technology. The process may therefore be perceived as a threat by individuals or organizations in dominant positions, who (consciously or otherwise) will seek to sideline or even reject it, for the sake of ‘expediency’. If such inclinations can be overcome, however, investment in such an approach is likely to produce better results in the technology adoption process, with ultimate beneficial consequences for ‘dominant’ and ‘subservient’ interests alike.
Fig. 1. Process leading to the creation of the decision-making team for health technology adoption.
1.2. What for?—the goal

What for?
- Once adopted, what does the new technology contribute?
- Does it fill an identified gap in current health care needs?

These questions ascertain the purpose and value of a new technology.

A need exists when the decision-maker has evidence that there is a discrepancy between the existing condition and an acceptable condition. Ideally, a full-scale needs assessment will provide required evidence on the relevant questions: Is there such a discrepancy? Is there any public expression of such a need or public support for filling the gap? Level of need can be gauged by examining frequency and intensity of need; that is, the number of people, or size of sub-population, and seriousness or gravity of need. It is also important to look at both current and future need, say five or ten years hence.

With telehealth for example, a gap might exist in access to specialty services for a geographically isolated community [10]. To document the discrepancy, information on the need for travel to seek specialty care (types and number of cases, and the frequency of travel) would be appropriate. It may also be possible to document foregone care and its consequences. From this information, the desired level of access can be estimated more appropriately.

Most challenging is estimating or measuring anticipated benefit in terms of health outcomes, and this is best achieved using the Comprehensive Framework. For example, an isolated Canadian community might report their most urgent needs as being: specialist support for difficult obstetrical deliveries at times when patients cannot be flown out; psycho-geriatric and pediatric assessment; and follow-up care in chronic conditions.

Needs-identification is the process of describing the problems of a target population, and the solution to these problems. Evaluation of need seeks to assess the importance and relevance of the problem and the solution. Thus, needs-analysis includes problem identification, solution identification, and ultimately, evaluation of both problem and solution.

Fig. 2 provides a simplified process for understanding the importance of the technology being considered for adoption, starting with a broad statement of current need. This is to be expressed at the level of population health (the health of the public), and in the light of established or accepted health goals. From this ‘big picture’ perspective, the expected objective of the technology under consideration can be articulated, expressed in terms of the improved health outcome of interest: Does the short-term objective (small picture) align with long-term goals (big picture)?

A positive answer to this question leads to the next: Is the contribution from the technology sufficiently large to warrant closer scrutiny? A clear and positive reply to this question would suggest it is feasible to move to the following step: considering the practical application of the decision framework.

1.3. How much and for whom?—the decision framework

Decisions about who gets how much of what in health care are made mostly in ad hoc, often partisan, fashion with different motives operating at different levels of decision-making. In the
broadest context, confronted with a choice among several technologies requiring allocation of limited resources, the policy-maker has a number of alternatives [8]:

(a) to decline consideration of the merits of each technology, and simply to divide the resources equally; that is, giving to each an equal share of (most likely inadequate) resources;
(b) to evaluate resource requirements of each technology, and then give each an equal percentage of its request; that is, relative resource requirements are allocated to all;
(c) to choose the technology that can assist the neediest or the most ill; that is, the technology able to rescue those nearest death;
(d) to choose the technology promising long-range efficiency and effectiveness; that is, a technology with a prevention emphasis which does not entail expensive or ineffective rescue efforts;
(e) to choose the technology able to provide effective help for the largest number of individuals; that is, a technology offering ‘the greatest good for the greatest number’ (utility and equity);
(f) to choose the technology of greatest value to those whose condition is caused or exacerbated by previous social or economic injustices; that is, on the principle of restorative justice;
(g) to choose the technology of service to those treated previously, or to whom one owes fidelity due to previous commitments; that is, to honour long-standing obligations;
(h) to use the lottery approach, drawing the winner from a hat.

How much and for whom?

- Once adopted, how much will the new technology improve individuals’ well-being? Whose well-being?
- How much of an impact will the new technology have within the different contexts of societal well-being?

These questions identify the ‘beneficiaries’ and quantify the ‘benefit’ resulting from the adoption of a new technology.

A decision framework which considers these alternatives and rationalizes choices between technologies in terms of equity and utility is arguably more useful than a priority classification scheme divorced from considerations of health consequences of the technology. Justice, in the context of health care, means equitable access to all effective health care which society can afford. This also implies that the decision-maker employs norms of utility as well as equity in making a decision. Utility, in this context, denotes highest/best return on the investment, that is, the greatest good to the largest number of people.

2. The framework

Building on previous studies on the subject [11–13], the framework for technology decisions in health care was developed incorporating four key dimensions (see Table 1). The first three dimensions—epidemiological context (population at risk, and population impact), economic context, and broad social context (including ethical, legal, and political concerns)—are descriptive elements of the health issue in question and the social environmental context within which the issue is defined. The fourth component—technology assessment activity—is the development of scientific evidence about the health issue and/or the technology used to tackle the issue. It represents a ‘quality of scientific knowledge’ perspective which provides information on the strength and quality of the evidence about a technology or health program.
### Table 1
Framework for health technology decisions

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Indicators</th>
<th>Target/goal (examples)</th>
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<tbody>
<tr>
<td>Population at risk&lt;sup&gt;a&lt;/sup&gt;</td>
<td>• Mortality; death rates, cause-specific death rates, proportionate mortality ratio, case-fatality ratio&lt;br&gt; • Epidemiological orientation&lt;br&gt; • Health systems research orientation&lt;br&gt; Use of health services&lt;br&gt; Access to services and geographic indicators&lt;br&gt; • Impact of violence on health&lt;br&gt; • Lifestyle-related health indicators</td>
<td>• Reduced health deficits of the population&lt;br&gt; • Increased accessibility to services&lt;br&gt; • Healthier lifestyle</td>
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<tr>
<td>Population impact&lt;sup&gt;a&lt;/sup&gt;</td>
<td>• Disability: functional or physiological (quality of well-being); for example: functional assessment inventory, sickness impact profile, Nottingham health-profile, quality of well-being scale, social relationship scale&lt;br&gt; • Potential impact: “etiological fraction” Quality of life</td>
<td>• Improved quality of life and well-being&lt;br&gt; Reduced burden of illness</td>
</tr>
<tr>
<td>Economic concerns</td>
<td>• Cost-effectiveness analysis&lt;br&gt; • Cost-benefit analysis&lt;br&gt; • Cost-utility analysis&lt;br&gt; • Public vs. private interests&lt;br&gt; • Opportunity costs</td>
<td>• Optimization of total social returns by weighing estimated costs and perceived benefits&lt;br&gt; • Recognition of allocative efficiency</td>
</tr>
<tr>
<td>Social context&lt;sup&gt;b&lt;/sup&gt;</td>
<td>• Social context&lt;br&gt; • Individuals (by gender)&lt;br&gt; • Communities&lt;br&gt; • Organizations and groups&lt;br&gt; • Institutions and systems&lt;br&gt; • Ethical acceptance&lt;br&gt; • Political will&lt;br&gt; • Legal framework&lt;br&gt; • Power and dominance issues</td>
<td>• Balanced gender&lt;br&gt; participation in decision-making&lt;br&gt; Gauging political will&lt;br&gt; Development of legal perspective</td>
</tr>
<tr>
<td>Technology assessment activity</td>
<td>• Comprehensiveness of scientific evidence&lt;br&gt; • Role of scientific evidence&lt;br&gt; • Quality of scientific evidence&lt;br&gt; • Source of scientific evidence&lt;br&gt; • Convergence of scientific evidence</td>
<td>• Increased understanding of conflicting interests&lt;br&gt; • Improved relevance of evaluative research</td>
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<sup>a</sup>Of problem, disease or health issue. All indicators should be by gender, age and cultural group

<sup>b</sup>Including ethical, legal and political concerns.

Having recognized the importance of considering all possible impact domains of the new technology, the first task is to assign a relative weight of importance to the different dimensions. Stakeholders and interest groups will tend to consider their own area as being more important than others, but a
productive debate within the decision-making team should reach an acceptable consensus: Are the population health issues more important than the ethical implications of the technology? Is the safety issue less important than economic concerns? Is equity a strong principle for the decision-makers? Are political reasons swaying the decision one way or another? These are global questions intended to make the value system behind the decision explicit, and therefore to identify the information needs of the decision-makers.

3. Indicators

All the above-mentioned dimensions of the Framework are dependent on appropriate indicators (empirical measures) used to define and accurately describe the specific policy issues of importance to the decision-making team.

The availability and quality of the scientific evidence are therefore important factors for using a critical approach. It should not be supposed, however, that the lack of accurate data will necessarily obstruct the decision-making process, since raising a set of appropriate questions about the broader context of health and human needs is itself a desirable objective. Nor is this approach solely ‘positivist’, that is, considering only needs for which appropriate measures are immediately available. Again, to ask the right questions is to take the necessary first step in identifying both immediate and long-term information needs.

By using the proposed Framework, both explicit deliberation of each separate policy dimension, and the incorporation of overall, integral consequences as seen from a societal perspective, can be realized. It may also be expected that the potential contribution of research to health sector policy-making will emerge clearly.

4. Information systems evaluation

What does the Comprehensive Framework offer in the evaluation of health information systems? Other frameworks exist which aim for comprehensiveness, and which acknowledge that systems impact complex social and behavioural processes [14]. Their scope, however, is primarily limited to impacts on the organizational setting of application. Evaluation approaches which do not go beyond organizational interests preclude the consideration of more widespread population or political impacts. Although this type of evaluation is to a large degree driven by organizational requirements, it does not follow that an approach which yields only limited answers is suitable for higher level purposes.

Some evaluation approaches have been developed to provide ‘for-profit’ corporations with guidance in making decisions on information systems investment [15]. Such methods will in all probability prove insufficient if applied to health care delivery systems, since the latter cannot neglect the broader impacts which investment-focussed evaluations do not address.

The need for a Framework which examines impacts comprehensively has been cogently argued by Roberts and Rigby as particularly necessary for emerging telehealth applications:

There is the potential for telemedicine radically to reshape health care provision; however there has been little consideration of the balance between positive and negative changes in general application, which could fundamentally alter the client practitioner relationship that has been
the model for medical care since Hippocrates. The literature, and practical observation, both show that the principal driving forces are financial, specialist clinical interest, and proof of technological feasibility. Unfortunately, and inappropriately, patient views and interests, societal effects, quality controls, and wider organisational effects are seldom considered. [16]

The method that these authors have developed to address deficiencies in current evaluative processes focusses on patients and society as primary stakeholders. Their approach is congruent with the Framework proposed here, but has been developed in the exclusive context of telemedicine applications.

Unlike the evaluative frameworks which have been explicitly and exclusively developed for information system evaluation (e.g. the social interactionist framework of Kaplan [17,18]), the Comprehensive Framework is most suitable for decision-makers who need to compare the impact of information system technologies within a framework that is inclusive of all competing health technologies.

While the Framework is especially suitable for generating summative evaluations for policy and administrative decision making, it can equally well produce useful questions for information system developers when carrying out formative evaluations. For example, information system evaluation approaches focussing on performance in achieving immediate goals of a particular application, such as quality of information retrieval [19], may benefit from a consideration of the wider social, political, and economic impacts of improvements (or deficits) in goal attainment.

5. Summary

This paper develops and describes a Comprehensive Health Technology Assessment Framework, capable of guiding rational decision-making about the adoption of new health technology. We raise three questions essential to this type of process: Who?; What for?; and How much and for whom? The answers will identify the people influenced by and influencing the decision, ascertain the purpose and value of the new technology, identify the beneficiaries, and quantify the benefit.

The major dimensions of the framework are (1) population at risk, (2) population impact, (3) economic concerns, (4) social context (including ethical, legal, and political concerns) and (5) technology assessment information (Table 1). Decision-makers assign a relative weight of importance to the different dimensions. These are further quantified by using appropriate indicators.

The Framework has several features of significance. First, by virtue of its comprehensive nature covering multiple dimensions of concern, the Framework process seeks the inclusion of all stakeholders, as presented in Fig. 1. It provides the opportunity to align local (or sub-population, or stakeholder) ‘wants’ with population health ‘needs’, as indicated in Fig. 2.

Second, it provides guidelines within which appropriate information is sought, developed and examined. This is achieved through raising a series of questions for which the answers (i.e. indicators) may be readily available, or may need further elaboration and information development.

Third, the Framework draws on a number of disciplinary perspectives, incorporating theories of epidemiology, sociology, economics, and systems science; and applies critical theory to health care evaluation.

Finally, application of the Framework helps identify possible choices by providing an evaluation of the relative socio-medical merits of technological alternatives under consideration. The decision-maker still makes the choice, but cognizant of its various and often far-reaching conse-
quences, and pursuant to performance standards that the decision-maker or the system have established.

The proposed Framework has greater power than existing frameworks in the evaluation of information systems in health care. It aims to identify all relevant interest groups, and, through comparison of the wider social and political impact of information system technologies, to place competing technologies within a consistent and defensible process of assessment.

References

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