Towards an Evaluation Framework for Electronic Health Records Initiatives: A Proposal For an Evaluation Framework

March 2004

Prepared as a component of the study:

Towards an Evaluation Framework for Electronic Health Record Initiatives:
A Review and Assessment of Methods used to Measure the Impact of
Health Information Systems Projects

Doreen Neville, ScD
Kayla Gates, BSc
Donald MacDonald, BSc
Mike Barron, MBA
Shelia Tucker, MLIS
Sandra Cotton, BA
Gerard Farrell, MD
Theodore Hoekman, PhD
Stephen Bornstein, PhD
Stephen O'Reilly, MBA

This study was made possible through funding by Health Canada, Office of Health and the Information Highway, Knowledge Development and Exchange (KDE) Applied Research Initiative and through contributions by the Newfoundland and Labrador Centre for Health Information (NLCHI) and the Newfoundland and Labrador Centre for Applied Health Research (NLCHAR).

Table of Contents

BACKGROUND

An Electronic Health Record (EHR) provides each individual with a secure and private lifetime record of their key health history and care within a health system. The record is available electronically to authorized health care providers and the individual anywhere, anytime, in support of high quality care. Recognizing the importance of the EHR in improving the quality and efficiency of health care, the federal government of Canada, in 2001, established Canada Health Infoway to support and accelerate the development and adoption of interoperable Electronic Health Records solutions across the country. Four core components have been identified as the key building blocks of an EHR by Infoway and the Newfoundland and Labrador Centre for Health Information (NLCHI): (1) a unique personal identifier/client registry; (2) a pharmacy network; (3) a laboratory network; and (4) a diagnostic imaging network.

Towards an Evaluation Framework for Electronic Health Records Initiatives: A Review and Assessment of Methods used to Measure the Impact of Health Information Systems Projects, a project funded by Health Canada, Office of Health and the Information Highway, was carried out between May 2002 and December 2003. The goals of the project were to: (a) review current approaches to evaluating the impact of health information systems (particularly those leading to an EHR); and (b) develop an evaluation framework which addresses the information needs of key stakeholders and the identified best practices in the evaluation of such initiatives. Three deliverables were produced from the project and released as separate (but complementary) documents:

1. Towards an Evaluation Framework for Electronic Health Records: An Inventory of Health Electronic Health Records Initiatives Across Canada;
2. Towards an Evaluation Framework for Electronic Health Records: An Annotated Bibliography and Systematic Assessment of the Published Literature and Project Reports**;**
3. **Towards an Evaluation Framework for Electronic Health Records: A Proposal for an Evaluation Framework**.

This report presents the Proposal for an Evaluation Framework. The project was guided by an advisory committee comprised of key personnel who are leading the work of NLCHI around the development of EHRs, including the Chief Executive Officer, the Health Information Network Project Leader, the Director of Research and Development, the Director of Standards Development, the Director of Communications and Privacy, and the project's principal research investigator.

PROCESS USED TO DEVELOP THE FRAMEWORK

The following process was used to develop the proposed evaluation framework:

1. A comprehensive search of the literature concerning the evaluation of complex health information systems, particularly those most closely related to the development of an Electronic Health Record, was conducted and used to generate a synthesis of the literature around evaluation efforts in this field and to outline a preliminary draft of an evaluation framework.

2. A summary of the current (as of May 2003) Electronic Health Records Initiatives across Canada was produced and provided to key informants in each jurisdiction for verification and revision as required.

3. During the course of this project, the Principal Investigator, Dr. Doreen Neville, was a Canadian Associate in the Commonwealth Harkness Program in International Health Policy. Dr. Neville presented the work in progress on the evaluation framework in bimonthly forums attended by a number international health policy experts and sought additional feedback from experts familiar with information system development throughout the year. At the final reporting seminar in Nashville, Tennessee in June 2003, a preliminary evaluation framework was presented and feedback received was incorporated into the framework.

4. In July 2003, participants were provided with both the inventory of current Electronic Health Record Initiatives Across Canada and the preliminary evaluation framework and asked to rank their priority evaluation questions within the 3 time frames proposed by the model (pre-implementation, implementation process and implementation impact). A total of 19 participants across Canada provided feedback on the proposed evaluation framework.

5. The feedback received from participants was used to further refine the proposed evaluation framework.

6. The framework document was then prefaced by a synopsis of the literature, which provides an overview of approaches to evaluation of electronic health records related projects, including perspectives on evaluation, evaluation models and frameworks commonly used, and a summary of the key messages regarding future initiatives in evaluation in this field. In addition, appendices were attached which provide a sample of evaluation questions and a menu of indicators used in previous studies or recommended for use in future evaluations.

NATURE OF THE INTERVENTION UNDER STUDY

As noted by Alvarez and Zelmer (1998), health information system initiatives across Canada share common goals, including: (1) integration of information systems to achieve a client focus and health services integration; (2) support for epidemiological research and health systems management; and (3) elimination of duplication and waste, with subsequent improvements of quality of care and reductions in cost. However, our review of the EHR initiatives in Canada (see the companion document *Towards an Evaluation Framework For Electronic Health Records: An Inventory of Electronic Health Records Initiatives Across Canada)* indicates that there is little uniformity in the design and planned implementation of the identified core components of an EHR (Unique Personal Identifier/Client Registry; Pharmacy Network, Laboratory Network and Diagnostic Imaging Network). Each jurisdiction has a differently configured legacy system upon which it is building its EHR and the form of the intervention under study is not consistent across the country. While this situation is not unique to Canadian health information systems initiatives (Healthfield 1999), the nature of the Canadian EHR interventions has implications for the types of evaluation approaches which will be most appropriate, as noted throughout the discussion of the literature which follows and the design of the proposed evaluation framework presented in this document.

SYNOPSIS OF THE LITERATURE

Critical appraisal of the published literature and project reports (see the companion document *Towards an Evaluation Framework for Electronic Health Records Initiatives: An Annotated Bibliography and Systematic Assessment of The Published Literature and Program Reports*) revealed that there is a dearth of information regarding evaluation of geographically dispersed health information systems. Most evaluations of information systems in health care have dealt with relatively small scale initiatives, wherein new technologies replace the existing (usually paper-based) system. The setting for most evaluation studies is within a hospital or a limited hospital to physician office interface (for example, enabling access to lab test results). Search of the literature did not detect a single study that describes the evaluation of a system with all four core components of an Electronic Health Record (EHR), although several large scale Health Information Systems initiatives were very similar in their goals and level of technical complexity. We identified a total of 93 articles/reports which were germane to the development of an evaluation framework in this field, and these were described in the Annotated Bibliography. In addition, several seminal texts in the field were reviewed and considered in the development of the proposed evaluation framework.

Burkle, Ammenwerth, Prokosch and Dudeck (2001) concluded, following a review of evaluations of clinical information systems, that a generic approach to evaluation does not exist; the evaluation approach depends on available resources, goals of the evaluation and the type of technology that is being examined. While we concur with this assessment, we feel that there is value in highlighting several aspects of evaluation of health information systems which inform the task at hand – development of an evaluation framework for Electronic Health Records Initiatives across Canada.

In the synopsis of the literature below, we provide an overview of approaches to evaluation of complex health information systems, including: (1) the most common perspectives on evaluation; (2) a brief description of some of the models and frameworks which have either been used to guide

previous evaluation efforts, are proposed for future evaluation projects, and/or have been developed by Canadian researchers; and (3) a summary of the key recommendations which emerged from the literature regarding future approaches to evaluation in this field.

Perspectives on Evaluation

Objectivist versus Subjectivist

One of the best known classifications of perspectives on evaluation of health information systems (objectivist versus subjectivist) was proposed by Friedman and Wyatt (1997). The objectivist perspective is one in which: (a) agreement exists regarding the aspects of a system which are important to measure; (b) "gold standards" in terms of optimal systems performance exist and the outcomes of a given system can be compared against these standards; (c) system attributes can be described and measured using quantitative methods, which permit precision in analysis of findings, and replication of study findings in other similar settings. The subjectivist perspective, in contrast, is one in which: (a) there are differing views on which aspects of a system are important to measure; (b) there is no "gold standard" against which to compare results and (c) qualitative methods are employed to understand the different opinions and conclusions legitimately reached by different observers in the same setting. The findings are not necessarily transferable to other settings, as the results are impacted by the context of the investigation.

Moehr (2002) reviewed the objectivist and subjectivist approaches proposed by Friedman and Wyatt in 1997, noting that these terms are preferable to the more common terms of quantitative and qualitative methods. Both quantitative and qualitative approaches are used in objectivist and subjectivist research, and the more important distinction is the focus on achieving maximum objectivity versus exploiting subjectivity in the investigation (p.114). Limitations of the objectivist approach to studying the complex world of health information systems include: (1) it is not possible to study the intervention in a vacuum, as health information systems are built to replace or complement existing systems, and instead of evaluating the impact of one new product you are evaluating the dynamic process of adaptation of a new information system; (2) rigorous comparison studies, including RCTs, consume tremendous resources such as time, money and personnel, and the results are often not available in a timeline where input to system redesign is feasible; (3) it is often not possible to adhere to the constraints of RCT design, i.e. it is not possible to randomly select hospitals and fit them with complex information systems in order to study their effects. Moehr proposes that the subjectivist approach holds more promise, in that it addresses what people really want or need to know, attempts to describe the health information system, environment and effects as perceived by people, using detailed observation and inductive reasoning. He suggests that methodological extensions such as: (a) the inclusion of systems engineering approaches in the early phases of system development, and (b) an assessment of cognitive and social effects in the operational phases is desirable.

Healthfield, Peel, Hudson, Key, Mackay, Marley, Nicholson, Roberts and Williams (1997) note that today we are faced with the evaluation of large scale health information system projects which are incrementally developed from legacy systems. Many methodological and practical problems arise which are different from the issues faced in the past, when evaluations of health information systems were concerned with relatively small scale initiatives which replaced or enhanced paper-based records. Hence, subjectivist approaches may be more appropriate for some of these new evaluation challenges.

Formative Versus Summative

Formative evaluation occurs while a program is still developing and can be modified on the basis of the findings. In formative studies, the role of the researcher is to feed back results to those involved in the evaluation in order to inform ongoing program planning, development and refinement (King, Lyons Morris and Fitzgibbon, 1987; Fulop, Allen, Clarke & Black, 2001). Formative evaluations may be quite simple or very complex, depending on the focus of the inquiry (Rossi and Freeman, 1993). Activities undertaken during the design and pre-testing of programs to guide the design process, as well as activities related to monitoring program implementation and progress reporting, are all examples of formative evaluation (King et al, 1997).

Summative evaluations occur after a program has been established and are used to determine what has been achieved as a result of the program, i.e. outcomes/impacts, attainment of goals, unanticipated consequences, and possibly comparisons with alternative programs (including the pre-existing program) in terms of efficiency and effectiveness.

Scientific Versus Pragmatic Evaluation Perspectives

Donald Campbell is perhaps the best known proponent of the “scientific” social science research paradigm, which supports the use of experimental methods in social science evaluation research. Scientific studies attempt to meet a set of design and conduct standards set by peers in their field and the value of their work is judged against these standards (Rossi and Freeman, 1993). Evaluation methods are ranked according to their capacity to link cause and effect and mediate threats to internal and external validity. The randomized clinical trial is considered to be the “gold standard” method for scientific evaluation research (Cook and Campbell, 1979).

The “pragmatic” perspective acknowledges that while scientific investigations and evaluation efforts may use the same logic of inquiry and the same research procedures, the intent of evaluation studies differentiates them from purely scientific investigations (Rossi and Freeman, 1993). The purpose of evaluation is to (a) produce maximally useful evidence within a specified budget and time constraints (Cronbach, 1982); and (b) address the policy and program interests of the sponsors and stakeholders (Rossi and Freeman, 1993).

Accountability, Developmental and Knowledge Perspectives

Heathfield and Pitty (1998) identify 3 general categories of perspectives on evaluation: The *accountability perspective* (wherein the task is to answer the question about whether a particular intervention caused a particular outcome, i.e. a cause and effect type question) usually involves the use of summative and quantitative methods, such as the use of randomized clinical trials. The *developmental perspective* (wherein the task is to strengthen institutions, improve agency performance or help managers with their planning, evaluating and reporting of tasks) usually involves formative evaluation methods (often qualitative but can be quantitative). The *knowledge perspective* (acquisition of a more profound understanding of some specific field) employs both qualitative and quantitative methods, dependent on the academic discipline of the researcher involved.

Heathfield and Pitty (1998) note that current health information system evaluations have tended to focus on the accountability perspective, with a subsequent pre-occupation with RCTs and quantitative approaches. They emphasize that new multi-method approaches are required. While sensitivity to accountability is heightened in resource-constrained times, they argue that evaluation focused on accountability in order to regain public trust is shortsighted and limits the gains that can be achieved from the developmental and knowledge perspectives on evaluation in the health information system field.

Models and Frameworks Commonly Used To Guide Evaluation Projects

The Delone and McLean Information Systems (IS) Success Model

In a landmark article, focusing primarily on Management Information System (MIS) applications, Delone and McLean (1992) provided a framework for characterizing and measuring the success of information systems. The framework includes 6 major dimensions or categories: system quality, information quality, use, user satisfaction, individual impact, and organizational impact. *System quality measures* (measures of the information processing system itself) tend to be engineering-oriented characteristics of the systems under study, such as response time, ease of use, system reliability, system accessibility, system flexibility and system integration. *Information quality measures* (measures of information system output) are addressed mostly from the perspective of the user and are therefore subjective in nature, such as information accuracy, timeliness, completeness, reliability, conciseness, and relevance. Frequently these measures are included as measures of user satisfaction as well. *Measures of information use* (recipient consumption of the output of an information system), including self-reported versus documented use, use by whom, frequency of use and extent of use, are valid only if system use is voluntary or discretionary. *Measures of user satisfaction* (recipient response to the use of the output of an information system) are the most widely utilized indicators of system success, primarily because of their inherent *face* validity, and the availability of reliable measurement instruments, such as satisfaction questionnaires. *Individual impact measures* (measures of the effect of information on the behavior of the recipient) are strongly tied to measures of performance, such as quality of decision making, change in decision behavior, time efficiency of task accomplishment, time to decision making, and confidence in decision making. Studies of this success indicator, while numerous, are most often undertaken in laboratory settings, using students and computer simulations. *Measures of organizational impact*

(the effect of information on organizational performance) have been derived primarily from the business sector and include cost reduction, cost effectiveness, contribution to profitability and return on investment (ROI).

The I/S success model is predicated on process and ecology concepts from the organizational effectiveness field, and proposes that success is a process construct which must include both temporal and causal influences on IS success. The authors suggest that there are many success measures which fall into the 6 dimensions described above. They emphasize that it is important to study the interrelationships among these dimensions, and to avoid arbitrarily selecting items from among the 6 dimensions to measure overall success if a clearer understanding of what constitutes information system success is to be achieved. They propose combining measures from the 6 categories to create a comprehensive measurement instrument. Furthermore, they suggest that selection of success measures should consider contingency variables, such as: the independent variables being researched, the size, structure, strategy and environment of the organization being studied, and the characteristics of the system itself.

In a ten-year follow-up article (DeLone and McLean, 2003), the authors provided a review *of* the I/S Success Model and an overview of how the model has been validated by research in the field. Suggestions for updating the model include; (1) adding a third dimension, “service quality” to the two original system characteristics, “system quality” and “information quality”; (2) substituting “intention to use” for “use” as a measure of system usage some contexts; and (3) combining the” individual impact” and “system impact” variables into a “net benefits” variable. They further suggest that the “net benefits” variable must be defined within the context of the system under study and within the frame of reference of those assessing the system impact, as these variables substantially influence what constitutes net benefits and hence IS success

Social Interactionist Models

Social Interactionist Models (Kaplan 1997, 1998) consider relationships between system characteristics, individual characteristics and organizational characteristics and the effects among them. Consequently, evaluations based on these models consider not only the impact of an information system on an organization, but also the impact of the organization on the information system, and tend to be process-focused. The framework is informed by theoretical models of organizational change, user reactions to health information systems and Rogers’ work on innovation diffusion (Rogers, 1993).

Evaluation questions within an interactionist framework address issues of Communication, Care, Control and Context (the 4 Cs). The evaluation questions are: (1) what are the anticipated long term impacts on the ways that departments linked by computers interact with each other; (2) what are the anticipated long term effects on the delivery of medical care; (3) will system implementation have an impact on control in the organization; and (4) to what extent do medical information systems have impacts that depend on the practice setting in which they are implemented?

Kaplan suggests that it is difficult to study processes over time and proposes five methodological guidelines that can be useful when developing a comprehensive evaluation framework. The evaluation framework should: (1) focus on a variety of technical, economic and organizational concerns; (2) use multiple methods; (3) be modifiable; (4) be longitudinal; and (5) be formative and summative

Cognitive Evaluation Approaches

Kushniruk, Patel and Cimino (1997) identify the need for improved methodologies for the assessment of medical systems and their user interfaces. Conventional methods of evaluation, such as questionnaires and interviews with users, rely on the user's memory of their experience with using a computer system (what they think they did when using the system) which may be quite different from their actual behavior. Therefore, there is a need to incorporate into system design and evaluation processes sound methodologies for the assessment of medical systems and their user interfaces.

Cognitive evaluation approaches encompass a continuum of methods ranging from experiments (laboratory based usability testing where test conditions are tightly controlled), to simulations (laboratory based low and high fidelity simulators) to naturalistic approaches (field based observations using ethnographic methods and unobtrusive recording). Methods which can be applied in the study of health information systems in both the laboratory and real life settings include (1) *usability testing* – evaluation of information systems that involves subjects who are representative of the target user population; (2) *cognitive task analysis* – characterization of the decision-making and reasoning skills of subjects as they perform activities involving the processing of complex information; and (3) *computer supported video analysis* - video recording of subjects as they interact with user interfaces in carrying our specific tasks. The 8 steps employed in carrying out cognitive evaluations of health care systems and user interfaces include: (1) development of the test plan; (2) study design, including selection of representative users; (3) selection of representative task /contexts; (4) set up of the test environment; (5) conducting the usability test; (6) data analysis; (7) recommendations to designers; (8) iterative input to design.

Kushniruk et al (1997) note that while cognitively-based usability testing can be applied throughout the lifecycle of information systems (from early formative evaluation during design work to summative evaluation to determine if a computer system has met usability criteria), their experience to date has found that the greatest benefits come from the formative analysis work (p. 221). Kushniruk (2002) suggests that future evaluation efforts with health information systems should integrate evaluation approaches which examine process variables (such as usability engineering) with approaches which address measurement of outcome variables

PROBE

The purpose of this document is to provide practical guidance for those involved in the evaluation of Electronic Patient and Health Records in the NHS in Britain and Wales. The PROBE (Project review and objective evaluation for electronic patient and health records projects) guidance was prepared by the UK Institute of Health Informatics for the NHS Information Authority (NHS Information Authority, March 2001), as an extension and update of the earlier PROBE guidance issued in 1996 by the NHS and as a companion document to the Evaluation of Electronic Patient and Health Records Projects document released in January 2001. It extends the original PROBE document in 2 ways: first by focusing on evaluation questions which are important to EPR/EHR projects and secondly by providing more detailed information about how to evaluate, including a review of the various tools and techniques available.

PROBE suggests that there are 4 essential standards for an evaluation study which need to be tested throughout the evaluation planning stage: utility, feasibility, propriety and accuracy. It also stresses the importance of an evaluation framework, which focuses stakeholders on the expected benefits and barriers of an EPR/EHR and methods of measuring these. The key principles of evaluation emphasized are the need for both formative and summative elements, advance planning, close integration to the project lifecycle, clearly defined aims and objectives, the inclusion of a before and after (comparative) element, and the collection of quantitative and qualitative data.

Six steps are proposed to plan an evaluation of an electronic patient record or electronic health record initiative: (1) agree why an evaluation is needed; (2) agree when to evaluate; (3) agree what to evaluate; (4) agree how to evaluate; (5) analyze and report; and (6) assess recommendations and decide on actions.

A suggested format for such an evaluation framework is a tabular summation of the following: (1) timing of the review, which includes recommendations for pre-implementation assessment of readiness to implement; implementation reviews carried out at each stage of the process, and operational evaluations which are carried out on the system as it is used in practice post implementation; (2) the research objectives/questions the system is designed to test (in the case of the NHS these questions were organized around 5 themes, which were strategic, technical, operational, human and financial considerations); (3) one or more specific measurement criteria for each research question; (4) the study design to be used; and (5) sources of data to be collected for each measurement criterion.

Total Quality Management (TQM**)**

Drazen and Little (1992) suggest that new approaches are needed to evaluate clinical and management applications of health information systems in order to measure benefits that are important to the institutional sponsors of health information system projects. Proposed enhancements to the traditional cost-benefit approach to evaluation include: (1) driving to achieve benefits as the primary evaluation goal, including more than direct cost savings, i.e. improvement in level of service and improvement in the outcomes of care; (2) focusing on critical issues and using standard tools to achieve efficiencies, i.e. measure what is important, not what is easy to measure; (3) maintaining independence, given the involvement of the private sector in many of the evaluation initiatives; (4) fitting with the institutional philosophy.

Drazen and Little (1992) propose a TQM framework for evaluation which incorporates the concept of continuous quality improvement. An example of a TQM approach to benefits assessment is then outlined: (1) identify improvement opportunities – identify the information processes that need improvement. If a large number of processes are identified, the priorities can be established by considering their importance to the multiple stakeholders, the difficulty in achieving improvement and the strategic importance of improvement; (2) understand priority processes, from the perspectives of relevant stakeholders; (3) find the root cause of the problem; (4) confirm the root cause; (5) identify improvement options; (6) track progress; and (7) monitor to insure continuous improvement.

The Team Methodology

A systems perspective informs the model developed by Grant, Plante and LeBlanc (2002) to evaluate the overall function and impact of an information system. Key tenets include: (1) the processing of information by a system can be distinguished at three different interacting levels: strategic, organizational, and operational, and these levels are a useful way of situating an evaluation; (2) the evaluation should be dynamic and include both formative and summative analyses; (3) the evaluation approach must be acceptable in terms of the resources and time it requires to complete; and (4) the evaluation should be longitudinal. The authors propose that an evaluation exercise should address the (a) who - role categories of persons who should participate in the evaluation; (b) when - time requirements and the timing of stages of evaluation; and (c) what - state the main and sub objectives of the evaluation exercise; the key perspectives which will be addressed, identify measures to be used and to specify the documentation required for the evaluation exercise.

Health Technology Assessment

Kazanjian and Green (2002) propose a Health Technology Assessment Framework as a conceptual tool for decision-making about health technologies, including information technologies. Although the Comprehensive Health Technology Assessment Framework discussed in this paper is primarily aimed at stakeholders involved in the adoption of new health technologies, the authors propose that it has relevance for decision makers who need to compare the impact of information system technologies within a framework that is inclusive of all competing health technologies. Impacts are considered at the societal level, not just the organizational setting in which the health information system is implemented, and from the perspective of patients and society as primary stakeholders. 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.

Framework for Action Research

Action research is an approach to conducting research which emphasizes the importance of doing research with and for people as opposed to on people; it focuses on generating knowledge about a social system and using that knowledge to change the system as part of the research process itself (Meyer, 2001, p 172-173). Lau (1999) notes that action research has been used in social sciences since the 1940s to integrate theory with practice through an iterative process of problem diagnosis, action intervention and reflective learning, but is still not well recognized as a method of inquiry among mainstream IS researchers and journals.

The four dimensions of the Framework for Action Research proposed by Lau are: (1) conceptual foundation; (2) study design to describe the methodological details; (3) the research process of diagnosis, actions, reflections and general lessons; and (4) the respective roles of the researcher and participants.

Four main role categories are identified: (1) those involved in the conception and design of the information system; (2) those who are responsible for the implementation and functioning of the system (specialist user); (3) those who use the system (end user) and (4) those who have a

stakeholder interest that the information system is a success. There is a requirement for a definition of evaluation priorities from each role category's point of view and a recognition by all of the constraints attached to the evaluation process so that the evaluation program is valid and achievable.

Balanced Score Card

The balanced scorecard (BSC) is a means to evaluate corporate performance from four different perspectives: the financial perspective, the internal business process perspective, the customer perspective, and the learning and growth perspective (Kaplan and Norton, 1992). When Denis Protti (founding Director of the School of Health Informatics, University of Victoria) was invited to assist in the development of the evaluation methodology for the NHS Information Strategy, he proposed the use of the BSC (Protti, 2002). Protti noted that investments in health information systems are costly ventures and frequently asked questions include concerns about the success of such systems and the degree to which substantial investment has proved worthwhile. Challenges to addressing these concerns include: (1) efficiency (doing things right) is easier to measure than effectiveness (doing the right thing); (2) new systems are intended to change difficult to measure actions; (3) strategic systems elude measurement; and (4) infrastructure investments can not be justified on a ROI basis. IT infrastructures, like many other public infrastructures such as roads and hospitals, require large long term investments and are difficult to cost-justify in advance. It is often difficult to show benefits in hindsight as well (p. 229).

Although the process of building a BSC for a health information systems initiative would not be simple, the author posits that the benefits would be worthwhile, as a BSC would allow managers to see the positive and negative impacts of information management and technology activities on the factors that are important to the National Health Service as a whole.

Key Messages Regarding Future Efforts To Evaluate Complex Health Information Systems

Green and Moehr (2002) have observed that the common core components of Canadian performance evaluation frameworks in health care include: clinical outcomes/effectiveness, accessibility, customer/stakeholder satisfaction; coordination; financial/efficiency, quality; innovation and internal business production. Less frequently included components are appropriateness, safety, health status and integration. No framework, except the Canadian Institute for Health Information (CIHI) framework, considers the optimal use of health information system capacity. This omission suggests that the integration of EHR initiatives into the overall strategic planning efforts of the Canadian health care system still has a long way to go.

Until Electronic Health Records are considered a key strategic initiative in the management and delivery of health services in Canada, difficulties in evaluating the impact of such initiatives will be compounded by lack of progress in implementation. Healthfield and Buchan (1996) described this quandary as a "catch 22" situation. Information technology initiatives are viewed with suspicion by many. Less than positive results from early evaluations (which focused solely on economic benefits) have mounted additional barriers to future system development. In most jurisdictions, decision makers, including the central funding agencies of government, require evidence to support the investment of millions of dollars in health information system infrastructure. However, until we first build the systems and simultaneously introduce broader evaluation, we will not have the evidence required to support nation-wide implementation of EHRs (Healthfied 1999).

Two very difficult general problems regarding evaluation of complex health information systems (such as Electronic Health Records or Electronic Patient Records) remain: (1) there are many versions of an EHR or EPR and no two implementation processes are alike, making comparisons difficult; and (2) there is a plethora of possible evaluation questions and it is difficult to decide which one to address (Healthfield, 1999). Some of the key messages extracted from the review of the literature concerning the need for broader, more inclusive, and yet flexible approaches to evaluation of complex health information systems include:

- A planned evaluation, introduced at the initial project stages, can help overcome many obstacles (Healthfield, 1999).

- It is important to develop a process for engaging stakeholders, particularly physicians, in establishing principles and premises for large IS projects (Protti, 2002).

- Evaluation frameworks should: (1) focus on a variety of technical, economic and organizational concerns; (2) use multiple methods; (3) be modifiable; (4) be longitudinal; and (5) be formative and summative (Kaplan, 1997).

- Many formal evaluations of major information technology investments in the public sector have focused on critiques of implementation rather than assessment of health care benefits. The time has come to attempt to quantify benefits not just in organizational, business or financial terms, but also with respect to health outcomes and the intermediary variables which lead to improved health outcomes in the health care delivery system, including improved diagnosis, more effective treatment, more focus on prevention, less errors and more evidence-based decision making (Donaldson, 1996).

- Evaluation is not just for accountability, but also for development and knowledge building. Future evaluations should be multi-perspective, multi-method, include qualitative methods and involve diversely constituted research teams (Healthfield et al, 1998).

- Limitations of RCTs identified include: (1) low power - not enough observations (Burkle et al, 2001); (2) inability to blind subjects to their assigned group (Burkle et al, 2001); (3) costs (Healthfield et al, 1998); (4) limited external validity (Healthfield et al, 1998).

- When faced with the challenge of evaluating complex systems which have been implemented in a less than standardized fashion, it is reasonable to focus on the form and function of the systems implemented (i.e. the concept of a total health record) instead of trying to distinguish, for evaluation purposes, the difference between different systems (Healthfied, 1999).

- Lessons learned from the evaluation of district health information systems in South Africa include: (1) avoid the use of overly complex handbooks, guides to evaluation or instruments; (2) identify core evaluation criteria which can be used for either self assessment by the participating sites or as baseline assessments for the project as a whole; and (3) develop evaluation protocols in consultation with the sites (Hammer, 1999).

PROPOSED APPROACH TO PLANNING AN EVALUATION OF AN EHR INITIATIVE

The proposed approach to planning an evaluation of an EHR initiative presented below was informed by: (1) a review of the current EHR related initiatives across Canada (see Health Information Systems Inventory); (2) the team's personal involvement with EHR initiatives in Newfoundland and Labrador through the Newfoundland and Labrador Centre for Health Information (NLCHI); (3) a systematic review of the literature (see synthesis above and the Annotated Bibliography); and (4) feedback from key informants on earlier drafts of the framework.

This framework is designed to be a guide to designing an evaluation initiative which is useful to a wide range of stakeholders involved in EHR initiatives across Canada, including those who fund the system development and implementation, policy makers, decision makers at all levels of the system, users of the system, and researchers. It is not an academic document, and it does not propose a conceptual model for understanding the design, implementation or impact of complex health information systems. Rather, it seeks to provide a practical guide to the types of questions which can be asked of the EHR initiatives, the options available to address these questions, and some of the tradeoffs that will occur if one or another approach to evaluation is selected. As a guide, it is illustrative, not exhaustive.

Our review of the EHR initiatives in Canada indicates that there is little uniformity in the design and planned implementation of the identified core components of an EHR (Unique Personal Identifier/Client Registry; Pharmacy Network, Laboratory Network and Diagnostic Imaging Network), and each jurisdiction has a different configuration of legacy system upon which it is building its EHR. Faced with a similar scenario in the National Health Service in the United Kingdom, evaluators such as Heathfield and colleagues (1999) chose to study the system in terms of form and functionality (i.e. the Electronic Health Record), as opposed to distinguishing between different systems for evaluation purposes. In the evaluation framework presented below, the system can refer to the full EHR in each jurisdiction, or to one or more subcomponents of the EHR, irrespective of the particular technology which was implemented to achieve the desired functionality.

We hope that this framework will serve as a springboard and guide for discussions among key stakeholders regarding what is important to measure about the EHR initiatives in Canada, and how to feasibly address it in a rigorous manner. If the framework is used in several jurisdictions, then it will be possible to begin identifying common evaluation priorities, track and compare evaluation questions and methods, begin to compile a national inventory of EHR evaluation projects, and identify opportunities for collaborative projects across jurisdictions and stakeholder groups.

STEPS FOR FRAMEWORK DEVELOPMENT

The framework is organized around several steps, as presented below, and is complemented with appendices which provide source data for some of the questions and indicators.

Step 1: Identification of Key Stakeholders in Each Jurisdiction

We have identified several categories of stakeholders who would be considered core to an evaluation of the full EHR initiative in each jurisdiction. Readers will note that representatives of a variety of both national and provincial/territorial sectors are included in this list. It is important that a wide range of stakeholders be involved in and apprised of the evaluation efforts within their own jurisdictions. It is also crucial that a number of individuals and organizations are aware of the initiatives across the country, because it will improve the likelihood that: (1) evaluation of EHR initiatives will get on and remain on the radar of these organizations as a strategic initiative and one which requires dedicated resources for input; (2) greater strategic alignment between the goals of the broader health system and the goals of the EHR initiatives will occur; (3) information exchange across jurisdictions will occur; (4) comparable evaluation approaches will be introduced across the country where feasible; (5) long term, stable champions for evaluation of EHR initiatives will be engaged at both the national and provincial/territorial levels.

KEY STAKEHOLDERS TO INITIALLY ENGAGE IN PLANNING FOR EVALUATION

FUNDERS	HEALTH SYSTEM ADMINISTRATION	OTHER HEALTH SYSTEM – RELATED AGENCIES	USER GROUPS	RESEARCHERS/ACADEMICS

• Provincial Government
  ➢ Treasury Board
  ➢ Chief Information Officers
  ➢ Health Department Personnel
• Provincial Organizations with the mandate to build EHRs (such as NLCHI, WellNet)
• INFOWAY
• Private Sector/IT companies if public/private partnerships are in place
	• CEOs
	• VPs Finance
	• Information Technology Managers
	• Medical Administrators
	• Nursing Administrators
	• Managers of other clinical departments impacted by the EHR initiative
		• Canadian Institute of Health Information
		• Canadian Office of Health Technology Assessment
		• F/P/T Council of Deputy Ministers
		• Privacy Advocates
		• Patient/Consumer Groups
			• Physicians
			• Nurses
			• Pharmacists
			• Laboratory technologists
			• IT support personnel
			• Patients
				• Canadian Institute of Health Information
				• Canadian Health Services Research Foundation
				• Provincial Health Services Research Foundations
				• University Faculties (Business, Economics, Nursing, Medicine, Pharmacy, Computer Science, Psychology, Sociology etc.)

Step 2: Orient Key Stakeholders to the EHR Initiative and Reach Agreement on WHY an Evaluation is Needed

It is important to orient key stakeholders to the EHR initiative and the evaluation process as early as possible, to determine their: (a) expectations of the EHR initiatives in their jurisdiction and (b) views on what an evaluation plan should address. A workshop format has proved useful for this type of stakeholder engagement, wherein an overview of the EHR initiative is presented; expectations documented and views on evaluation elicited.

Healthfield (1998) suggests that there are three general types of rationale for why evaluation is conducted in the field of health information systems: (1) to insure accountability for expenditure of resources; (2) to develop and strengthen performance of agencies, individuals and/or systems; and (3) to develop new knowledge. Given the diversity of key stakeholders involved with EHR initiatives, it is highly likely that they will identify different rationales for conducting evaluation. For example, one could expect that individuals/agencies responsible for the administration of public funds would highlight accountability as a major reason for evaluation; clinicians and administrators would be most interested in performance enhancements, and academics would likely value most highly the opportunity to gain new knowledge in their respective fields.

While each of these rationales for evaluation may consider evidence collected by a variety of approaches, both qualitative and quantitative, they carry with them: (1) assumptions about what evaluation can contribute; (2) orientation towards particular evaluation methods; and (3) requirements in terms of the timelines and resources necessary to address them.

RATIONALE FOR EVALUATION	ASSUMPTIONS	EVALUATION METHODS	REQUIREMENTS
ACCOUNTABILITY: (measurement of results, such as efficiency, effectiveness, impacts on costs, health outcomes etc)	1. Interventions result in outcomes which can be accurately measured. 2. There is a "gold standard" against which results can be compared to determine if they are positive. 3. The measuring process does not affect the intervention under study. 4. Numerical measurement is superior because it allows statistical analysis.	• Summative • Economic evaluations, such as cost effectiveness analysis, cost benefit analysis, cost minimization analysis • Randomized Clinical Trial, quasi-experimental designs, before and after studies	• Pre and post implementation data collection • Long time period • Resource intensive • Provides data on impact and outcomes • Results not necessarily generalizeable but important to show trends in the findings across jurisdictions

RATIONALE FOR EVALUATION	ASSUMPTIONS	EVALUATION METHODS	REQUIREMENTS
PERFORMANCE ENHANCEMENT: (evaluation to improve the performance of individuals/ organizations)	1. Providing people/organizations with feedback about their performance empowers them to improve their performance. 2. There is no gold standard; results obtained from observation are dependent on the context and the observer. 3. Understanding and documenting differences of opinion is an important part of evaluation; subjectivity is ok. 4. Qualitative data is valued for its richness and detail.	• Primarily qualitative data, observations, interviews • Quantitative methods also employed, primarily surveys	• Data collection during implementation and post implementation • Measurements pre – implementation desirable for many questions • Less costly than impact studies • Provides information about process which is important on its own but also helps interpret information gathered about impacts/outcomes.
KNOWLEDGE DEVELOPMENT: (to gain more in-depth understanding in some specific discipline or field	Dependent on the academic discipline, the research orientation of the investigators and the research question being addressed.	• Academic discipline • May include qualitative methods, quantitative methods or both	• Dependent on study design • Essential to moving the field of health informatics forward • Direct relevance of results not always obvious to practitioners

Step 3: Agree on When To Evaluate

Ideally, evaluation of complex information systems should involve longitudinal evaluation, that is, evaluation that occurs over time, and/or involves multiple data collection points (reference and rationale). We recommend that whenever possible, the evaluation of EHR projects in Canada involve data collection at 3 or more points: (1) baseline (pre-system implementation); (2) during implementation and (3) post implementation (preferably multiple measures at 6 and 12 months post implementation). We recognize that many jurisdictions have introduced (or are about to introduce) one of more components of a province wide EHR, and hence new baseline collection of data is not possible. However, pre-implementation data may be available from Scoping Exercises conducted prior to system implementation, or from separately conceived and completed evaluations of work flow, audits of patient charts, or research projects. Whenever pre-existing measures are available they should be noted so as to inform the design of any evaluation projects which are conducted during the implementation and post implementation phases.

Step 4: Agree on What to Evaluate

It is well recognized that there are virtually an endless number of research and evaluation questions which could be posed about complex health information systems such as the Canadian EHR initiatives (see Appendix A). However, resources to pursue these issues are limited, in terms of funding and availability of personnel with expertise to conduct the evaluation. Therefore it is very important that each jurisdiction feels that it is gaining the maximum benefit it can from the investment of scarce resources in evaluation. A priority setting exercise with key stakeholders is one way to (a) identify the questions that it is important to answer (versus the questions that it is easy to answer) and (b) insure that all key stakeholders have an investment in the evaluation projects which are undertaken. If the evaluation framework proposed in this document experiences wide uptake across Canada, there will also be an opportunity to avoid duplication of effort where possible, or to strengthen the design of a project by conducting it simultaneously in more than one jurisdiction. One approach to priority setting would be to build on the stakeholder identification of why an evaluation is important (accountability, performance enhancement and/or knowledge development) and then identify core and optional questions within each category.

Step 5: Agree on How to Evaluate

As noted above, both the rationale for undertaking evaluation, and the particular questions which are important to each stakeholder, have implications for the methods which can be used to conduct the evaluation. The following tables (pg 23) provide an illustration of Steps 4 and 5, with a sample of potential core questions for each evaluation period and category highlighted in bold type.

A discussion of the most feasible methods for approaching the selected evaluation questions will involve consideration of the tradeoffs involved with the methods chosen. Each jurisdiction will need to consider the resources they have available to devote to the evaluation and determine the best use of those resources in terms of evaluation questions addressed and methods used. In addition, we support the recommendations of Kaplan (1997) that all jurisdictions undertake an evaluation which: (a) focuses on a variety of concerns; (b) uses multiple methods: (c) is modifiable; (d) is longitudinal; and (e) includes both formative and summative approaches (formative evaluation involves mostly process evaluation of a system during implementation; summative evaluation assesses a system once it has been implemented and operational for a period of time). Grant et al (2002) further suggest that the evaluation be timely, realistic, practical and endorsed by key stakeholders. The current thinking around evaluation of complex health information systems leans towards evaluation geared to performance enhancement and knowledge development, and away from accountability, particularly costing approaches to net benefits assessments. However, accountability remains a strong value in Canadian society in general and increasingly in the health and technology sector, and therefore we recommend that some type of accountability question be included in the evaluation approaches in each jurisdiction.

Step 6: Analyze and Report

Many researchers have noted that the task of consolidating the findings of a multi-method evaluation is perhaps the most difficult component of the study of complex health information systems (Healthfield et al, 1999; Herbst et al, 1999; Moehr, 2002; Lau, 1999). It is likely that most jurisdictions will select one or more evaluation questions to address, and the evaluation effort will consist of several sub-components which are in fact separate evaluation projects, involving different methods and disciplines. We recommend that the findings from each evaluation project within the evaluation initiative be shared with those key stakeholders identified in Step 1, preferably in a workshop setting. This approach will permit fuller discussion of the interpretation and implications of the results obtained through different projects, or through the use of multiple methods within each project.

Step 7: Agree on Recommendations and Forward Them to Key Stakeholders

The network of key stakeholders attending the Workshop (Step 6) are also those who should be involved in generating the recommendations which arise from the findings of the evaluation. Those responsible for knowledge-generation oriented studies will have responsibilities to generate recommendations specific to their discipline/field of inquiry. These recommendations may prove to be relatively straightforward and not subject to much broad debate *within the evaluation team*; the debates which occur in academic circles may be more contentious but of little direct impact on the evaluation team as a whole. Development oriented studies will face more discussion from the evaluation team and hence disagreements regarding recommendations may arise. Accountability-oriented studies, which impact on all evaluation team members (and on the users and funders of the information system initiatives), can anticipate more lively debate regarding interpretation of findings. Subsequent development of recommendations, particularly if the recommendations arising are negative in terms of continuation of the initiative, may be challenging.

There is no guarantee that the process of engagement used to generate the evaluation questions and approaches will ensure a consistent interpretation of what recommendations can be supported by the results. There is however a greater likelihood that common stances on at least some of the key issues will be found if those involved are: (a) familiar with the main issues from the start; (b) aware of the different perspectives each team member brings to the discussion; and (c) comfortable that the variety of methods used in the evaluation produced the most unbiased results possible.

PROPOSED FRAMEWORK: TIME FRAMES, CORE QUESTIONS, INDICATORS, DATA SOURCES AND STUDY DESIGN

EVALUATION FOR ACCOUNTABILITY: MEASUREMENT OF RESULTS

TIME FRAME	SAMPLE QUESTIONS	INDICATORS	DATA SOURCES	STUDY DESIGN
Pre-Implementation	**1. What are the predicted benefits and costs of this system?**	• Projections of system : - costs - benefits - return on investment (ROI)	• Project scoping documentation • Business case	• Descriptive
	2. Does this investment fit strategically with the direction and priorities in the jurisdiction?	• Support given to EHR type systems development in the past, financial/political • Recognition of the role of IS in other policy initiatives, i.e. primary care, regionalization, wellness, move to evidenced – based decision-making	• Government and organizational strategic plans, annual reports, mission statements • Interviews with key stakeholders	
	3. Are the necessary management structures in place?	• project management documents • standards • privacy protocols	• Project scoping documentation • Internal policy documents	

EVALUATION FOR ACCOUNTABILITY: MEASUREMENT OF RESULTS

TIME FRAME	SAMPLE QUESTIONS	INDICATORS	DATA SOURCES	STUDY DESIGN*
Implementation and Post-Implementation (Most studies with an accountability focus will build on pre-implementation documentation and then require data collection towards the end of the implementation period and at least one point (preferably 2 or more) post-implementation (i.e. 6 months and 12 months post implementation)	**1. What were the costs of implementing this system and how do they compare with projected costs**?	• Cost of the technology • Personnel costs • Cost of training/ user support	• Project budget documents • Host budget documents	• Economic evaluations such as cost effectiveness analysis and cost benefit analysis • Before and after studies
	2. What benefits were achieved and how do they compare with projected benefits? • **Clinical benefits**	• Avoidance of errors • Avoidance of adverse events • Improved patient outcomes • Improved information quality	• Quality and performance indicators • Clinical indicators • System logs and audit trails	• Before and after studies • Randomized clinical trials

EVALUATION FOR ACCOUNTABILITY: MEASUREMENT OF RESULTS

TIME FRAME	SAMPLE QUESTIONS	INDICATORS	DATA SOURCES	STUDY DESIGN*
Implementation and Post-Implementation (Most studies with an accountability focus will build on pre-implementation documentation and then require data collection towards the end of the implementation period and at least one point (preferably 2 or more) post-implementation (i.e. 6 months and 12 months post implementation)	**2. What benefits were achieved and how do they compare with projected benefits?** • **Administrative benefits**	• Improved communications • Enhanced capacity to achieve strategic goals	• Interviews with key personnel • System logs and audit trails	• Before and after studies • Repeated measures studies • Randomized clinical trials
	• **Economic/resource benefits**	• Operating costs • Length of stay • Use of unnecessary tests • Visits per clinician • Waiting times	• Operational budgets • Chart audits • Interviews with clinicians and patients • Scheduling records	• Before and After Studies • Repeated measures studies • Randomized Clinical Trials • Useability engineering studies

EVALUATION FOR PERFORMANCE ENHANCEMENT

TIME FRAME	SAMPLE QUESTIONS	INDICATORS	DATA SOURCES	STUDY DESIGN
Pre-Implementation	**1. What is the state of readiness within the sites for implementation of the system?**	• Training and support programs in place • Project management structures in place • Security/privacy structures in place	• System implementation plan • Privacy policy statements • Privacy impact statements	• Descriptive
	2. What are the expectations and concerns of key stakeholders?	Stated expectations for the system's impact on: • patient safety • clinical productivity • relationship with patients • costs • privacy • communication	• Surveys • Questionnaires • Interviews • Focus groups	• Descriptive; cross-sectional data collection; • May be used as baseline data for comparative study designs in the implementation and post implementation phases.

EVALUATION FOR PERFORMANCE ENHANCEMENT

TIME FRAME	SAMPLE QUESTIONS	INDICATORS	DATA SOURCES	STUDY DESIGN
Pre-Implementation (Con't)	**3. What are the current levels of data quality?**	• Data availability • Data completeness • Data accurateness	• Project scoping documents • Current indicators and benchmarks • Quality indicators • Current audits	• Descriptive; can be used as baseline for before and after studies.
	4. Is the new system technically able to perform the functions it is expected to?	• Data availability • Data completeness • Data accurateness	• Prototype testing • On-site pilot testing	• Usability engineering approaches, usability testing • Usability walkthrough • Design walkthrough usually laboratory based with a high degree of experimental control.

EVALUATION FOR PERFORMANCE ENHANCEMENT

TIME FRAME	SAMPLE QUESTIONS	INDICATORS	DATA SOURCES	STUDY DESIGN
Pre-Implementation (Con't)	**5. What are the current work processes in the areas which will be impacted by the new system?**	• Patient scheduling • Discharge planning • Medication prescribing • Turn around time for lab and diagnostic tests • Access to clinical information when needed • Workflow analysis • Analysis of decision-making	• Project scoping documents • Current indicators and benchmarks • Quality indicators • Current audits • Interviews • Observations	• Descriptive; may be used for baseline in before and after studies.

EVALUATION FOR PERFORMANCE ENHANCEMENT

TIME FRAME	SAMPLE QUESTIONS	INDICATORS	DATA SOURCES	STUDY DESIGN
Implementation and Post Implementation	**1. Is this system useable?**	• system response times • user satisfaction with user interface and system functionality • time for task completion • ease of access	• Observations • Video analysis • Interviews with users	• Usability testing approaches; • Descriptive methods in the setting; may involve some laboratory simulations
	2. Does the system deliver the information clinicians and managers need to make decisions?	• time to complete tasks • use of the system to make decisions • routine use of the system	• Observations • Video analysis • Interviews with users • System audits • System logs	• Descriptive; may be used as part of a before and after study or a repeated measures study • Useability engineering approaches

EVALUATION FOR PERFORMANCE ENHANCEMENT

TIME FRAME	SAMPLE QUESTIONS	INDICATORS	DATA SOURCES	STUDY DESIGN
Implementation and Post Implementation	**3. Is the necessary level of support available to individuals to allow them to use the system efficiently and effectively?**	• Routine use of the system • Use of on-line help functions • Use of technical support personnel • Time to complete tasks	• Questionnaires • Surveys • Interviews • Focus groups • Observation	• Repeat measures, during implementation and post-implementation. • Usability studies in the setting to evaluate how well the system supports clinical and management decision-making.
	4. Is the implementation proceeding as anticipated?	• Implementation timelines • Change requests • Costs	• Project management records • Observations • Interviews • Focus groups	• Repeat measures, during implementation and immediately post implementation.

EVALUATION FOR KNOWLEDGE DEVELOPMENT*

Time Frame	Sample Questions	Indicators	Study Designs/Discipline Approaches
Pre-Implementation	**1. Can the costs and benefits of these EHR systems be quantified?**	• Validity and reliability estimates of cost and benefit indicators	• Econometric measurement approaches such as cost effectiveness analysis.
	2. How may information technologies be tailored for use by a wide variety of individuals in a wide variety of places?	• User performance in simulations • User feedback • Task analysis	• Cognitive psychology approaches • Useability engineering

*The majority of these sample questions were extracted from the article by Kaplan and colleagues, 2001, titled '**Towards an Informatics Research Agenda: Key People and Organizational Issues**". There are a tremendous variety of evaluation research questions, disciplines with expertise to address them, and potential study designs and information sources, as summarized in the description of this article in Appendix B.

EVALUATION FOR KNOWLEDGE DEVELOPMENT*

TIME FRAME	SAMPLE QUESTIONS	INDICATORS	STUDY DESIGNS/DISCIPLINE APPROACHES
Implementation and Post- Implementation	**1. What is a successful implementation of an information system and what is the best way to measure it?**	Delone and MacLean (1992 and 2003) suggest • information quality • system quality • service quality • use/intention to use • user satisfaction • net benefits	• Variety of study designs, usually comparative, some before and after studies and some RCTs.
	2. How do linkages through IT affect organizational identity and integrity?	• Workflow processes • Communication patterns • Workforce satisfaction • Workforce loyalty • Strategic use of IT in decision making	• Social/interactionalist • Sociology/organizational behavior • Mainly qualitative methods

*The majority of these sample questions were extracted from the article by Kaplan and colleagues, 2001, titled '**Towards an Informatics Research Agenda: Key People and Organizational Issues**". There are a tremendous variety of evaluation research questions, disciplines with expertise to address them, and potential study designs and information sources, as summarized in the description of this article in Appendix B.

CONCLUDING REMARKS

As noted above, this framework is meant to serve as a template for the design and conduct of evaluation studies to assess the Electronic Health Records initiatives in Canada. We hope that the seven step approach outlined in this framework document resonates with key stakeholders as a practical and useful guide.

As a guide, this framework is illustrative, not exhaustive. The appendices do however provide a large inventory of additional potential evaluation questions and indicators to choose from, and this information is supplemented by the companion document to this report: *Towards An Evaluation Framework for Electronic Health Records: An Annotated Bibliography and Systematic Assessment of the Published Literature and Program Reports* (Neville et al, February 2004).

There are several key points that we would like to emphasize in our closing comments:

- In Canada today, we have a tremendous opportunity to collaborate across jurisdictions and stakeholder groups to develop: (1) a standardized approach to assessment of EHR initiatives and (2) a national inventory of evaluation protocols, instruments and evidence. If this framework serves as a springboard for discussion among key stakeholders regarding what is important to measure about EHR initiatives in Canada and how to measure it, then we will have laid a foundation upon which common evaluation priorities across jurisdictions can be identified and pursued.

- It is crucial that collaborative evaluation efforts around EHR initiatives focus on the functionality of the systems being introduced, as opposed to the specific form of the technology being employed. This is not to suggest that there is no need for evaluation of proprietary technology, but rather to urge the key stakeholders identified in this document to find ways to work together to answer the big picture questions around the implementation of EHRs.

- It is important to be clear about what you hope to learn from an evaluation, and your underlying assumptions about what evaluation can and cannot achieve. We recommend use of the accountability/performance enhancement/knowledge development classification of perspectives presented in this framework to: (a) stimulate discussion among stakeholders about their primary rationale for expending scarce resources on evaluation activities and (b) aid the group to identify the types of tradeoffs which will be required as a consequence of the evaluation questions they pursue and the resources they can access to complete the study.

- This framework document and its companion documents are designed as a springboard for future discussion and dialogue, and as such will be widely circulated. Comments and suggestions should be directed to:

Doreen Neville, ScD
Associate Professor,
Health Policy and Health Care Delivery
Faculty of Medicine
Memorial University of Newfoundland

Email: dneville@mun.ca
Phone: 709-777-6215
Fax: 709-777-7382

The research team would like to express its sincere appreciation to all the key informants who assisted with the development of this framework.
***Thank you very much*!**

BIBLIOGRAPHY

Adams WG, Mann AM, Bauchner HB. Use of an electronic medical record improves the quality of urban pediatric primary care. Pediatrics 2003; 111:626-632.

Adragna L. Implementing the enterprise master patient index. Journal of AHIMA 1998; 69(9):46-52.

Aller RD. Creating integrated regional laboratory networks. Clinics in Laboratory Medicine 1999; 19(2): 299-316.

Alvarez R. The promise of e-health - a Canadian perspective. EHealth International 2002; 1(1):4.

Alvarez RC, Zelmer J. Standardization in health informatics in Canada. International Journal of Medical Informatics 1998; 48(1-3):13-18.

Amatayakul M. Critical success factors - steps to take to achieve a truly integrated information system. Health Management Technology 2000; 21(5):14-18.

Anderson J, Aydin C, Jay S. (Eds). Evaluating Health Care Information Systems: Methods and Applications. Thousand Oaks, California: Sage Publications, 1994.

Anderson J, Jay S, Anderson M, Hunt T. Evaluating the potential effectiveness of using computerized information systems to prevent adverse drug events. Proc AMIA Symp 1997; 228-232.

Anderson JG. Evaluation in health informatics: computer simulation. Computers in Biology and Medicine 2002; 32(3):151-164.

Anonymous. Computerized provider order entry systems. Health Devices 2001; 30(9-10):323-359.

Aspinall MB, Whittle J, Aspinall SL, Maher RLJ, Good CB. Improving adverse-drug-reaction reporting in ambulatory care clinics at a Veterans Affairs hospital. American Journal of Health System Pharmacy 2002; 59(9):841-845.

Bakker AR, Leguit FA. Evolution of an integrated HIS in the Netherlands. International Journal of Medical Informatics 1999; 54(3):209-224.

Balas EA. Information systems can prevent errors and improve quality. Journal of the American Medical Informatics Association 2001; 8(4):398-399.

Baldwin FD. Once is enough. Healthcare Informatics 2001(July); 30-33.

Bamford W, Rogers N, Kassam M, Rashbass J, Furness P. The development and evaluation of the UK national telepathology network. Histopathology 2003; 42:110-119.

Baorto DM, Cimino JJ, Parvin CA, Kahn MG. Using Logical Observation Identifier Names and Codes (LOINC) to exchange laboratory data among three academic hospitals. Proc AMIA Symp 1997; 96-100.

Bates D, Leape L, Cullen D, Laird N, Petersen L, Teich J et al. Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. Journal of the American Medical Association 1998; 280(15):1311-1316.

Bates DW, Teich JM, Lee J, Seger D, Kuperman GJ, Ma'Luf N et al. The impact of computerized physician order entry on medication error prevention. Journal of the American Medical Informatics Association 1999; 6(4):313-321.

Bates DW, Gawande AA. Improving safety with information technology. New England Journal of Medicine 2003; 348(25):2526-2534.

Bates DW, Pappius E, Kuperman GJ, Sittig D, Burstin H, Fairchild D et al. Using information systems to measure and improve quality. International Journal of Medical Informatics 1999; 53(2-3):115-124.

Bayegan E, Nytro O, Grimsmo A. Ranking of information in the computerized problem-oriented patient record. Medinfo 2001; 10(Pt 1):594-598.

Bayegan E, Nytro O. A problem-oriented, knowledge-based patient record system. Studies in Health Technology and Informatics, Health Data in Information Society (Volume 90), Proceedings of MIE2002 2002.

Bayegan E, Tu S. The helpful patient record system: problem-oriented and knowledged-based. Proc AMIA Symp 2002; 36-40.

Benjamin SD. The electronic clinical patient record. Practical Procedures and Aesthetic Dentistry 2001; 13(9):744-748.

Bingham A. Computerized patient records benefit physician offices. Healthcare Financial Management 1997; 51(9):68-70.

Birkmeyer CM, Bates DW, Birkmeyer JD. Will electronic order entry reduce health care costs? Effective Clinical Practice 2002; 5(2):67-74.

Blaine GJ, Cox JR, Jost RG. Networks for electronic radiology. Radiologic Clinics of North America 1996; 34(3):505-524.

Bodenheimer T, Grumbach K. Electronic technology: a spark to revitalize primary care? JAMA 2003; 290(2):259-264.

Bomba D, de Silva A. An Australian case study of patient attitudes towards the use of computerised medical records and unique identifiers. Medinfo 2001; 10(Pt 2):1430-1434.

Branger P, Duisterhout J. Electronic data interchange in medical care: an evaluation study. Proc Annu Symp Comput Appl Med Care 1991; 58-62.

Branger P, van der Wouden, Schudel B, Verboog E, Duisterhout J, van der Lei J et al. Electronic communication between providers of primary and secondary care. BMJ 1992; 305(6861):1068-1070.

Brennan S, Dodds B. The electronic patient record programme: a voyage of discovery. The British Journal of Healthcare Computing and Information Management 1997; 14:16-18.

Brown SH, Hardenbrook S, Herrick L, St.Onge J, Bailey K, Elkin PL. Usability evaluation of the progress note construction set. Proc AMIA Symp 2001; 76-80.

Buffone GJ, Petermann CA, Bobroff RB, Moore DM, Dargahi R, Moreau DR et al. A proposed architecture for ambulatory systems development. Medinfo 1995; 8(Pt 1):363-366.

Burgess B, Wager KA, Lee FW, Glorioso R, Bergstrom L. Clinics go electronic: two stories from the field. Journal of the American Health Informatics Management Association 1999; 70(6):42-46.

Burkle T, Ammenwerth E, Prokosch H, Dudeck J. Evaluation of clinical information systems. What can be evaluated and what cannot? Journal of Evaluation in Clinical Practice 2001; 7(4):373-385.

Bush J. Computers: looking for a good electronic medical record system? Family Practice Management 2002; 9(1):50-51.

Canfield K. Clinical resource auditing and decision support for computerized patient record systems: a mediated architecture approach. Journal of Medical Systems 1994; 18(3):139-150.

Carine F, Parrent N. Improving patient identification data on the patient master index. Health Information Management 1999; 29(1):14-17.

Chin HL, McClure P. Evaluating a comprehensive outpatient clinical information system: A case study and model for system evaluation. Proc Annu Symp Comput Appl Med Care 1995; 717-721.

Chin HL, Krall MA. Successful implementation of a comprehensive computer-based patient record system in Kaiser Permanente Northwest: strategy and experience. Effective Clinical Practice 1998; 1(2):51-60.

Chin HL. Embedding guidelines into direct physician order entry: simple methods, powerful results. Proc AMIA Symp 1999; 221-225.

Chronbach LJ. Designing Evaluations of Educational and Social Programs. San Francisco: Jessey-Bass, 1982.

Cimino JJ, Li J, Mendonca EA, Sungupta S, Patel VL, Kushniruk AW. An evaluation of patient access to their electronic medical records via the world wide web. Proc AMIA Symp 2000; 151-155.

Claflin N. Computerized interdisciplinary assessment. Journal for Healthcare Quality 2000; 22(2):25-33.

Connelly DP. Integrating integrated laboratory information into health care delivery systems. Clinics in Laboratory Medicine 1999; 19(2):277-297.

Cook TD, Campbell DT. Quasi-Experimentation: Design and Analysis Issues for Field Settings. Boston: Houghton Mifflin Company, 1979.

Covvey HD. IT capabilities for the realization of the laboratory without walls. Proc AMIA Symp 1996; 613-617.

Creighton C. A literature review on communication between picture archiving and communication systems and radiology information systems and/or hospital information systems. Journal of Digital Imaging 1999; 12(3):138-143.

Cupito M. How to find who. Health Management Technology 1998; 19(6):32-37.

Darbyshire P. User-friendliness of computerized information systems. Computers in Nursing 2000; 18(2):93-99.

Dayhoff RE, Kuzmak PM, Frank SA, Kirin G. Extending the multimedia patient record across the wide area network. Proc AMIA Symp 1996; 653-657.

DeLone W, McLean E. Information systems success: the quest for the dependent variable. Information Systems Research 1992; 3(1):60-95.

DeLone W, McLean E. The DeLone and McLean Model of Information Systems Success: A ten-year update. Journal of Management Information Systems 2003; 19(4):9-30.

Donaldson LJ. From black bag to black box: will computers improve the NHS? BMJ 1996; 312(7043):1371-1372.

Doran B, DePalma JA. Plan to assess the value of computerized documentation system: adaptation for an emergency department. Topics in Emergency Medicine 1996; 18(1):63-73.

Doupnik AM. An overview of electronic document management system product offerings. Topics in Health Information Management 2002; 23(1):62-73.

Drazen E. Why don't we have computer-based patient records? Journal of the American Health Informatics Management Association 1996; 67(6):56-60.

Drazen EL, Little AD. Beyond Cost Benefit: An assessment approach for the 90's. AMIA 1992: 113-17

Drazen E, Waegemann CP. Point counterpoint - computer-based patient record. Healthcare Informatics 1998; 15(5):84-96.

Drazen E. Is this the year of the computer-based patient record? Healthcare Informatics 2001; 18(2):94-98.

Effler P, Ching-Lee M, Bogard A, Ieong MC, Nekomoto T, Jernigan D. Statewide system of electronic notifiable disease reporting from clinical laboratories. Journal of the American Medical Association 1999; 282(19):1845-1850.

Elson RB, & Connelly DP. Computerized patient records in primary care: Their role in mediating guideline-driven physician behaviour change. Archives of Family Medicine 1995; 4(8):698-705.

Endoh A, Minato K, Komori M, Inoue Y, Nagata S, Takahashi T. Quantitative comparison of human computer interaction for direct prescription entry systems. Medinfo 1995; 8(Pt 2):1101-1105.

Fletcher RD, Dayhoff, R.E., Frank S, Jones R, Wu C et al. The integrated multimedia electronic patient record. 1999.

Fletcher RD, Dayhoff RE, Wu CM, Graves A, Jones RE. Computerized medical records in the Department of Veterans Affairs. Cancer 2001; 91(8 suppl):1603-1606.

Forsythe DE, Buchanan B. Broadening our approach to evaluating medical information systems. Proc Annu Symp Comput Appl Med Care 1991; 8-12.

Francis L, Hebert M. Experiences from Health Information System Implementation Projects Reported in Canada Between 1991 and 1997. Journal of End User Computing 2001; 13(4):17-25.

Freriks G. Identification in healthcare: Is there a place for unique patient identifiers? Is there a place for the master patient index? 2000.

Gadd CS, Penrod LE. Assessing physician attitudes regarding use of an outpatient EMR: A longitudinal, multi-practice study. Proc AMIA Symp 2001; 194-198.

Gadd CS, Friedman CP, Douglas G, Miller DJ. Information resources assessment of a healthcare integrated delivery system. Proc AMIA Symp 1999; 525-529.

Gamm L, Barsukiewiez C, Dansky K, Vasey J. Pre- and post- control model research on end-users' satisfaction with an electronic medical record: preliminary results. Proc AMIA Symp 1998; 225-229.

Gardner J. VA leads the way. Modern Healthcare 1997; 27(48):24.

Gates K. Evaluation of a system for electronic exchange of laboratory information: A pre-implementation study. Master's Thesis, Memorial University Faculty of Medicine, March 2004.

Goddard BL. Termination of a contract to implement an enterprise electronic medical record system. Journal of the American Medical Informatics Association 2000; 7(6):564-568.

Golob R, Quinn J. Goals & roles: integrated delivery systems & the master patient index. Healthcare Informatics 1994; 11(11):68-72.

Grant A, Plante I, Leblanc F. The TEAM methodology for the evaluation of information systems in biomedicine. Computers in Biology and Medicine 2002; 32(3):195-207.

Green CJ, Moehr JR. Performance evaluation frameworks for vertically integrated health care systems: shifting paradigms. Proc AMIA Symp 2000; 315-319.

Greenes RA, Peleg M, Boxwala A, Tu S, Patel V, Shortliffe EH. Sharable computer-based clinical practice guidelines: rationale, obstacles, approaches, and prospects. Medinfo 2001; 10(Pt 1):201-205.

Gritzalis DA. Enhancing security and improving interoperability in healthcare information systems. Medical Informatics (Lond) 1998; 23(4):309-323.

Gustafson DH, Hawkins RP, Boberg EW, Bricker E, Pingree S, & Chan CL. The use and impact of a computer-based support system for people living with AIDS and HIV infection. Proc Annu Symp on Comput Appl Med Care 1994; 604-608.

Gustafson DH, Hawkins R, Boberg E, Pingree S, Serlin RE, Graziano F et al. Impact of a patient-centered, computer-based health information/support system. American Journal of Preventive Medicine 1999; 16(1):1-9.

Hammond WE, Hales JW, Lobach DF, Straube MJ. Integration of a computer-based patient record system into the primary care setting. Computers in Nursing 1997; 152(2 Suppl):S61-S68.

Hanmer L. Criteria for the evaluation of district health information systems. International Journal of Medical Informatics 1999; 56(1-3):161-168.

Hassey A, Gerret D, Wilson A. A survey of validity and utility of electronic patient records in a general practice. BMJ 2001; 322(7299):1401-1405.

Hawkins F. Evaluation of clinical documentation before and after EMR implementation. IT Health Care Strategist 2000; 2(12):8-11.

Hawkins HH, Hawkins RW, Johnson E. A computerized physician order entry system for the promotion of ordering compliance and appropriate test utilization. Journal of Healthcare Information Management 1999; 13(3):63-72.

Heathfield H, Pitty D, Hanka R. Evaluating information technology in health care: barriers and challenges. BMJ 1998; 316(7149):1959-1961.

Heathfield H, Hudson P, Kay S, Mackay L, Marley T, Nicholson L et al. Issues in the multi-disciplinary assessment of healthcare information systems. Journal of Information Technology and People 1999; 12(3):253-275.

Heathfield HA, Buchan IE. Current evaluations of information technology in health care are often Inadequate. BMJ 1996; 313(7063):1008-1009.

Heathfield HA, Peel V, Hudson P, Kay S, Mackay L, Marley T et al. Evaluating large scale health information systems: from practice towards theory. Proc AMIA Ann Symp 1997; 116-120.

Heathfield HA, Pitty D. Evaluation as a tool to increase knowledge in healthcare informatics. Medinfo 1998; 9(Pt 2):879-883.

Herbst K, Littlejohns P, Rawlinson J, Collinson M, Wyatt JC. Evaluating computerized health information systems: hardware, software, and human-ware: experiences from the Northern Province, South Africa. Journal of Public Health Medicine 1999; 21(3):305-310.

Hersh WR, Patterson PK, Kraemer DF. Telehealth: the need for evaluation redux. Journal AMIA 2002; 9(1):89-91.

Hippisley-Cox J, Pringle M, Cater R, Wynn A, Hammersley V, Coupland C et al. The electronic patient record in primary care - regression or progression? A cross sectional study. British Medical Journal 2003; 326(7404):1439-1443.

Hocking J, Brown G, Malyuk D, Ensom R. Computerized integration of pharmacy and laboratory data: a prototype model. The Canadian Journal of Hospital Pharmacy 1993; 46(5):212-214.

Hripcsak G, Wilcox A. Reference standards, judges, and comparison subjects: roles for experts in evaluating system performance. Journal of the American Medical Informatics Association 2002; 9(1):1-15.

Jerant AF, Hill DB. Does the use of electronic medical records improve surrogate patient outcomes in outpatient settings? Journal of Family Practice 2000; 49(4):349-357.

Johnson SB, Haug P, Curtis C, Defa T, Davoren B, Kolodner R et al. Where are they now? CPR leaders assess their progress. Journal of AHIMA 2000; 71(8):35-39.

Kaplan B. Initial Impact of a clinical laboratory computer system: themes common to expectations and actualities. Journal of Medical Systems 1987; 11(2/3):137-147.

Kaplan B. An evaluation model for clinical information systems: clinical imaging systems. Medinfo 1995; 8(Pt 2):1087.

Kaplan B. Addressing organizational issues into the evaluation of medical systems. Journal of the American Medical Informatics Association 1997; 4(2):94-101.

Kaplan B. Social Interactionist framework for information systems studies: the 4C's. Proc of the IFIP WG 8 2 and 8 6 Joint Working Conference on Information Systems: Current Issues and Future Changes 1998; 327-339.

Kaplan B, Brennan PF, Dowling AF, Friedman CP, Peel V. Towards an informatics research agenda. Journal of the American Medical Informatics Association 2001; 8(3):235-241.

Kaplan B, Lundsgaarde HP. Toward an evaluation of an integrated clinical imaging system: identifying clinical benefits. Methods of Information in Medicine 1996; 35(3):221-229.

Kaplan R, Norton D. The balanced scorecard – measures that drive performance. Harvard Business Review. 1992; 70(1):71-79.

Karmel M. The electronic medical record: good-bye paper charts, hello better patient care. Minnesota Medicine 2002; 85(3): 57-59.

Kazanjian A, Green CJ. Beyond effectiveness: the evaluation of information systems using a comprehensive health technology assessment framework. Computers in Biology and Medicine 2002; 32(3):165-177.

Keshavjee K, Troyan S, VanderMolen D. Measuring the success of electronic medical record implementation using electronic and survey data. Proc AMIA Symp 2001; 309-312

King JA, Morris LL, Fitz-Gibbon CT. How to Asses Program Implementation. Thousand Oaks, California: Sage Publications, 1987.

Kozyrskyj A, Brown T, Mustard C. Community pharmacist perceptions of a provincial drug utilization database. Canadian Pharmaceutical Journal 1998; 131:24-29.

Kozyrskyj AL, Mustard CA. Validation of an electronic, population-based prescription database. Annals of Pharmacotherapy 1998; 32(11):1152-1157.

Krall MA. Acceptance and performance by clinicians using an ambulatory electronic medical record in an HMO. Proc Annu Symp Comput Appl Med Care 1995; 708-711.

Kuhn KA, Giuse DA. From hospital information systems to health information systems: problems, challenges, perspectives. Methods of Information in Medicine 2001; 40(4):275-287.

Kukafka R, O'Carroll PW, Gerberding JL, Shortliffe EH, Aliferis C, Lumpkin JR et al. Issues and opportunities in public health informatics: a panel discussion. Public Health Management Practice 2001; 7(6):31-42.

Kushniruk A, Patel V, Cimino JJ, Barrows RA. Cognitive evaluation of the user interface and vocabulary of an outpatient information system. Proc AMIA Symp 1996; 22-26.

Kushniruk A. Evaluation in the design of health information systems: application of approaches emerging from usability engineering. Computers in Biology and Medicine 2002; 32(3):141-149.

Kushniruk AW, Kaufman DR, Patel VL, Levesque Y, Lottin P. Assessment of a computerized patient record system: a cognitive approach to evaluating medical technology. M D Computing 1996; 13(5):406-415.

Kushniruk AW, Patel VL, Cimino JJ. Usability testing in medical informatics: cognitive approaches to evaluation of information systems. Proc AMIA Annu Symp 1997; 218-222.

Kushniruk AW, Patel VL. Cognitive evaluation of decision making process and assessment of information technology in medicine. International Journal of Medical Informatics 1998; 51(2-3):83-90.

Kushniruk AW, Patel VL, Cimino JJ. Evaluation of web-based patient information resources: application in the assessment of a patient clinical information system. Proc AMIA Symp 2000; 443-447.

Kushniruk AW, Patel C, Patel VL, Cimino JJ. 'Televaluation' of clinical information systems: an integrative approach to assessing web-based systems. International Journal of Medical Informatics 2001; 61(1):45-70.

Larrabee JH, Boldreghini S, Elder-Sorrells K, Turner Z, Wender RG, Hart JM et al. Evaluation of documentation before and after implementation of a nursing information system in an acute care hospital. Computers in Nursing 2001; 19(2):56-65.

Lau F. Towards a framework for action research in information system studies. Information Technology and People 1999; 12 (2): 148-175.

Lau F, Hebert M. Experiences from health information system implementation projects reported in Canada between 1991 and 1997. Journal of End User Computing 2001: 13 (4): 17-25.

Lenson CM. Building a successful enterprise master patient index: a case study. Topics in Health Information Management 1998; 19(1):66-71.

Lim P. MediNet: Singapore's nationwide medical network. Annals of the Academy of Medicine, Singapore 1990; 19(5):656-661.

Lincoln MJ, Weir C, Moreshead G, Kolodner R, Williamson J. Creating and evaluating the Department of Veteran Affairs electronic medical record and national clinical lexicon. Proc Annu Symp Comput Appl Med Care 1994; 1047.

Littlejohns P, Cluzeau F. Guidelines for evaluation. Family Practice 2000; 17(Suppl 1):S3-S6.

Littlejohns P, Wyatt JC, Garvican L. Evaluating computerised health information systems: hard lesson still to be learnt. BMJ 2003; 326:860-863.

Litzelman D, Dittus R, Miller M, Tierney, W. Requiring physicians to respond to computerized reminders improves their compliance with preventive care protocols. Journal of General Internal Medicine 1993; 8(6):311-317.

Liu Z, Sakurai T, Orii T, Iga T, Kaihara S. Evaluations of the prescription order entry system for outpatient clinics by physicians in the 80 university hospitals in Japan. Medical Informatics and the Internet in Medicine 2000; 25(2):123-132.

Lock C. What value do computers provide to NHS hospitals? BMJ 1996; 312(7043):1407-1410.

Lovis C, Payne TH. Extending the VA CPRS electronic patient record order entry system using natural language processing techniques. Proc AMIA Symp 2000; 517-521.

MacDonald D. Pharmacist's Expectations of a Pharmacy Network: A Baseline Evaluation. Master's Thesis. Faculty of Medicine, Memorial University of Newfoundland, March 2004.

Malone PM, Young WW, Malesker MA. Wide-area network connecting a hospital drug informatics center with a university. American Journal of Health System Pharmacy 1998; 55(11):1146-1150.

Marshall PD, Chin HL. The effects of an electronic medical record on patient care: clinician attitudes in a large HMO. Proc AMIA Symp 1998;150-154.

Martin-Baranera M, Planas I, Palau J, Miralles M, Sancho J, Sanz F. Assessing physician's expectations and attitudes toward hospital information systems: The IMASIS experience. M D Computing 1999; 16(1):73-76.

Mast CG, Caruso MA, Gadd CS, Lowe HJ. Evaluation of a filmless radiology pilot - a preliminary report. Proc AMIA Symp 2001; 443-447.

Mathews KA. Evaluation of clinical information systems. Nursing Management 1993; 24(7):104-105.

Mattern WD, Scott S. A fully integrated clinical information system to support management of end-stage renal disease. Dis Manage Health Outcomes 2001; 9(11):619-629.

Meyer J. Action Research. In N Fulop, P Allen, A Clarke, N Black (eds) Studying the Organization and Delivery of Health Services. New York, NY: Routledge, 2001.

Mbananga N, Madale R, Becker P. Evaluation of hospital information system in the Northern Province in South Africa. Report prepared for the Health Systems Trust, 2002, Medical Research Council of South Africa.

McDaniel JG. Simulation studies of a wide area health care network. Proc Annu Symp Comput Appl Med Care 1994; 438-444.

Medical Records Institute, 2003. Overview of the MRI fifth annual survey of EHR trends and usage.

Meyers JS. Electronic medical records: 10 questions I didn't know to ask. American Academy of Family Physicians 2001; 8(3):29-32.

Miller R. Reference standards in evaluating system performance. Journal of the American Medical Informatics Association 2002; 9(1):87-88.

Mitchell E, Sullivan F. A descriptive feast but an evaluative famine: systematic review of published articles on primary care computing during 1980 - 1997. BMJ 2001; 322(7281):279-282.

Moczygemba J, Biedermann S. MPIs (master patient index) in healthcare: current trends and practices. Journal of AHIMA 2000; 71(4):55-60.

Modai I, Sigler M, Kurs R. The computerized lab alert system for patient management in clinical care. Psychiatric Services 1999; 50(7):869-885.

Moehr JR. Evaluation: salvation or nemesis of medical informatics? Computers in Biology and Medicine 2002; 32(3):113-125.

Monane M, Matthias D, Nagle B, Kelly M. Improving prescribing patterns for the elderly through online drug utilization review intervention. JAMA 1998; 280(14):1249-1252.

Murff HJ, Kannry J. Physician satisfaction with two order-entry systems. Journal of the American Medical Informatics Association 2001; 8(5):499-509.

Nazi KM. The journey to e-health: VA healthcare network upstate New York (VISN 2). Journal of Medical Systems 2003; 27(1):35-45.

Neame RL, Olson M. Measures implemented to project personal privacy for an on-line national patient index: a case study. Topics in Health Information Management 1996; 17(2):18-25.

Neville D, Keough M, Barron M, MacDonald D, Gates K, Tucker S, Cotton S, Farrell G, Hoekman T, Bornstein S, O'Reilly S. Towards an Evaluation Framework for Electronic Health Records: An Inventory of Electronic Health Records Across Canada. March 2004.

Neville D, Gates K, Tucker S, Keough M, MacDonald D, Barron M, Cotton S, Farrell G, Hoekman T, Bornstein S, O'Reilly S. Towards an Evaluation Framework For Electronic Health Records: An Annotated Bibliography and Systematic Assessment of the Published Literature and Program Reports. February 2004.

NHS Information Authority, 2001. PROBE: Project review and objective evaluation for electronic patient and health record projects. Prepared by the UK Institute of Health Informatics for ERDIP.

NHS Information Authority, 2001. Evaluation of electronic patient and health record projects. Prepared by the UK Institute of Health Informatics for the NHS Information Authority.

NHS Information Authority, March 2003. Electronic Record Development and Implementation Programme update. www.nhsia.nhs.uk/erdip/pages/publications/ERDIPUpdateJan03_5.pdf, Accessed September 2003.

Nielsen PE, Thomson BA, Jackson RB, Kosman K, Kiley KC. Standard obstetric record charting system: evaluation of a new electronic medical record. Obstetrics and Gynecology 2000; 96(6):1003-1008.

Ohmann C, Boy O, Yang Q. A systematic approach to the assessment of user satisfaction with health care systems: constructs, models and instruments. Studies in Health technology and Informatics 1997; 43(Pt B):781-785.

Ornstein SM, Jenkins RG, Edsall RL. Computerized patient systems: a survey of 28 vendors. Family Practice Management 1997; 4(10):45-59.

Ornstein SM. Electronic medical records in family practice: the time is now. The Journal of Family Practice 1997; 44(1):45-48.

Ornstein SM, Jenkins RG, MacFarlane LL, Glaser A, Snyder K, Gundrum T. Electronic medical records as tools for quality improvement in ambulatory practice: theory and a case study. Topics in Health Information Management 1998; 19(2):35-43.

Ornstein SM, MacFarlane LL, Jenkins RG, Pan Q, Wager KA. Medication cost information in a computer-based patient record system. Archives of Family Medicine 1999; 8(2):118-121.

Ornstein SM, Garr DR, Jenkins RG, Musham C, Hamadeh G, Lancaster C. Implementation and evaluation of a computer-based preventive services system. Family Medicine 1995; 27(4):260-266.

Osada M, Nishihara E. Implementation and evaluation of workflow based on hospital information system/radiology information system/picture archiving and communication systems. Journal of Digital Imaging 1999; 12(2 (Suppl 1)):103-105.

Ostbye T, Moen A, Erikssen G, Hurlen P. Introducing a module for laboratory test order entry and reporting of results at a hospital ward: an evaluation study using a multi-method approach. Journal of Medical Systems 1997; 21(2):107-117.

Patel VL, Kaufman DR, Allen VG, Shortliffe EH, Cimino JJ, Greenes RA. Toward a framework for computer-mediated collaborative design in medical informatics. Methods of Information in Medicine 1999; 38(3):158-176.

Patel VL, Kushniruk AW, Yang S, Yale J. Impact of a computer-based patient record system on data collection, knowledge organization, and reasoning. Journal of the American Medical Informatics Association 2000; 7(6):569-585.

Patel VL, Arocha JF, Kushniruk AW. Patients' and physicians' understanding of health and biomedical concepts: relationship of the design of EMR systems. Journal of Biomedical Informatics 2002; 35(1):8-16.

Poon EG, Kuperman GJ, Fiskio J, Bates DW. Real-time notification of laboratory data requested by users through alphanumeric pagers. Journal of the American Medical Informatics Association 2002; 9(3):217-222.

Powsner SM, Wyatt JC, Wright P. Opportunities for and challenges of computerisation. Lancet 1998; 352(9140):1617-1622.

Protti D, Peel V. Critical success factors for evolving a hospital toward an electronic patient record system: a case study of two different sites. Journal of Healthcare Information Management 1998; 12(4):29-38.

Protti D. A proposal to use a balanced scorecard to evaluate information for health: an information strategy for the modern NHS (1998 - 2005). Computers in Biology and Medicine 2002; 32(3):221-236.

Protti D. What can the American electronic health record (EHR) pioneers tell us about what it takes to be successful? Healthcare Management Forum 2002; 15(2):33-35.

Protti D. The power of principles and premises: using them to help define the EHR. Healthcare Management Forum 2002; 15(3):46-48.

Raschke RA, Gollihare B, Wunderlich TA, Guidry JR, Leibowitz AI, Peirce JC et al. A computer alert system to prevent injury from adverse drug events. Journal of the American Medical Informatics Association 1998; 280(15):1317-1320.

Rehm S, Kraft S. Electronic medical records: the FPM vendor survey. Family Practice Management 2001; 8(1):45-54.

Rigby M, Robins S. Practical success of an electronic patient record system in community care - a manifestation of the vision and discussion of the issues. International Journal of Bio-Medical Computing 1996; 42:117-122.

Rivkin S. Opportunities and challenges of electronic physician prescribing technology. Medical Interface 1997; 10(8):77-83.

Robbins J. The Northern Territory Client Master Index. Health Information Management 1999; 29(1): 35-37.

Robert G, Gabby J, Stevens A. Which are the best information sources for identifying emerging health care technologies? An international Delphi survey. International Journal of Technology Assessment in Health Care 1998; 14(4): 636-643.

Rogers E. Diffusion of Innovation (3rd edition). New York: The Free Press, 1993

Rossi PH, Freeman HE. Evaluation: A Systematic Approach 5. Newbury Park, California: Sage Publications, 1993.

Rothschild J, Lee T, Bae T, Bates D. Clinician use of a palmtop drug reference guide. Journal American Medical Informatics Association 2002; 9(3):223-229.

Sabo D. Clinical information systems: a gateway to the 21st century. Nursing Administration Quarterly 1997; 21(3):68-75.

Sado AS. Electronic medical records in the intensive care unit. Critical Care Clinics 1999; 15(3):499-522.

Safran C, Rind DM, Davis RB, Ives D, Sands DZ, Currier J et al. Guidelines for management of HIV infection with computer-based patient's record. Lancet 1995; 346(8971):341-346.

Safran C, Jones PC, Rind D, Bush B, Cytryn KN, Patel VL. Electronic communication and collaboration in a health care practice. Artificial Intelligence in Medicine 1998; 12(2):137-151.

Sailors RM, East TD. Clinical informatics: 2000 and beyond. Proc-AMIA-Symp 1999; 609-613.

Sarr MG. The electronic environment: how has it, how will it, and how should it affect us? Journal of Gastrointestinal Surgery 2001; 5(6):572-582.

Schiff GD, Rucker TD. Beyond structure-process-outcome: Donabedian's seven pillars and eleven buttresses of quality. Journal on Quality Improvement 2003; 27(3):169-174.

Schiff GD, Klass D, Peterson J, Shah G, Bates DW. Linking laboratory and Pharmacy: opportunities for reducing errors and improving care. Archives of Internal Medicine 2003; 163(8):893-900.

Schiff GD, Rucker TD. Computerized prescribing: building the electronic infrastructure for better medication usage. JAMA 1998; 279(13):1024-1029.

Schuerenberg K. Electronic records find long-term use: Remote access to patient records enables Denver physicians to provide better services to long-tem care patients. Health Data management February 2003.

Shortliffe EH. The evolution of health-care records in the era of the internet. Medinfo 1998; 9(Pt 1):8-14.

Shortliffe EH. Clinical information systems in the era of managed care. Transactions of the American Clinical and Climatological Association 1993; 105:203-215.

Shortliffe EH, Bleich HL, Caine CG, Masys DR, Simborg DW. The federal role in the health information infrastructure: a debate of the pros and cons of government intervention. Journal of the American Medical Informatics Association 1996; 3(4):249-257.

Shortliffe EH, Barnett GO, Cimino JJ, Greenes RA, Huff SM, Patel VL. Collaborative medical informatics research using the internet and the world wide web. Proc AMIA Annu Symp 1996; 125-129.

Shortliffe EH. The next generation internet and health care: a civics lesson for the informatics community. Proc AMIA Symp 1998; 8-14.

Shortliffe EH, Wiederhold G, Fagan LM. Medical Informatics: Computer Applications in Health Care. Reading, Massachusetts: Addison-Wesley Publishing Company, 1990.

Sittig DF, Kuperman GJ, Fiskio J. Evaluating physician satisfaction regarding user interactions with an electronic medical record system. Proc AMIA Symp 1999; 400-404.

Smith PD. Implementing an EMR system: one clinic's experience. Family Practice Management 2003; 10(5):37-42.

Snaedal J. The ethics of health sector databases. EHealth International 2002; 1(1):6-8.

Soliman F, Soar J. Physician clinical communication systems--an Australian perspective. Journal of Medical Systems 1997; 21(2):99-106.

Soper WD. Why I Love my EMR. Family Practice Management 2002; 9(9):35-38.

Stevens CA, Morris A, Sargent G. Internet health information sources. The Electronic Library 1996; 14(2):135-147.

Talmon J, Enning J, Castaneda G, Eurlings F, Hoyer D, Nykanen P et al. The VATAM guidelines. International Journal of Medical Informatics 1999; 56(1-3):107-115.

Tan LT. National patient master index in Singapore. International Journal of Bio-Medical Computing 1995; 40(2):89-93.

Tang P, LaRosa M, Gorden S. Use of computer-based records, completeness of documentation, and appropriateness of documented clinical decisions. Journal of the American Medical Informatics Association 1999; 6(3):245-251.

Tang PC, Fafchamps D, Shortliffe EH. Traditional medical records as a source of clinical data in outpatient setting. Proc Annu Symp Comput Appl Med Care 1994; 575-579.

Teich JM. Clinical information systems for integrated healthcare networks. Proc AMIA Symp 1998; 19-28.

Thiru K, Hassey A, Sullivan F. Systematic review of scope and quality of electronic patient record data in primary care. BMJ 2003; 326(7398):1070-1075.

Treweek S, Flottorp S. Using electronic medical records to evaluate healthcare interventions. Health Informatics Journal 2001; 7(2):96-102.

Twair AA, Torreggiani WC, Mahmud SM, Ramesh N, Hogan B. Significant savings in radiologic report turnaround time after implementation of a complete picture archiving and communication system (PACS). Journal of Digital Imaging 2000; 13(4):175-177.

van der Loo RP, van Gennip EMSJ, Bakker AR, Hasman A, Rutten FFH. Evaluation of automated information systems in health care: an approach to classifying evaluative studies. Computer Methods and Programs in Biomedicine 1995; 48(1-2):45-52.

Van der Meijden MJ, Tange HJ, Hasman TA. Determinants of success of inpatient clinical information systems: a literature review. Journal of the American Medical Informatics Association 2003; 20(3):235-243.

Villella R. Lab connections: building a case for a web-based lab results reporting system. Healthcare Informatics 2000; 17(10):119-120.

Waegemann CP. The five levels of the ultimate electronic health record. Healthcare Informatics 1995; 12(11):26-35.

Wager KA, Heda S, Austin CJ. Developing a health information network within an integrated delivery system: a case study. Topics in Health Information Management 1997; 17(3):20-31.

Wager KA, Ornstein SM, Jenkins RG. Perceived value of computer-based patient records among clinical users. M D Computing 1997; 14(5):334-340.

Wager KA, Lee FW, White AW, Ward DM, Ornstein SM. Impact of an Electronic Medical Record System on Community-based Primary Care Practices. The Journal of the American Board of Family Practice 2000; 13(5):338-348.

Walker A. South Australia: best practice guidelines for patient master index maintenance. Health Information Management 1999; 29(1):43-45.

Wang D, Peleg M, Tu S, Shortliffe EH, Greenes RA. Representation of clinical practice guidelines for computer-based implementations. Medinfo 2001; 10(Pt 1):285-289.

Weir C, Lincoln MJ, Roscoe D, Turner C, Moreshead G. Dimensions associated with successful implementation of a hospital based integrated order entry system. Proc Annu Symp on Comput Appl Med Care 1994; 653-657.

Weir CR. Linking information needs with evaluation: the role of task identification. Proc AMIA Symp 19998; 310-314.

Weir CR, Hurdle JF, Felgar MA, Hoffman JM, Roth B, Nebeker JR. Direct text entry in electronic progress notes. An evaluation of input errors. Methods of Information in Medicine 2003; 42(1):61-67.

Wenzel GR. Creating an interactive interdisciplinary electronic assessment. Computers, Informatics, Nursing 2002; 20(6):251-260.

Wills S. The 21st century laboratory: information technology and health care. Clinical Leadership Management Review 2000; 14(6):289-291.

Wolfe H. Cost-benefit of laboratory computer systems. Journal of Medical Systems 1986; 10(1):1-9.

Wu SC, Smith JW, Swan JE. Pilot study on the effects of a computer-based medical image system. Proc AMIA Symp 1996; 674-678.

APPENDIX A

EVALUATION of COMPLEX HEALTH INFORMATION SYSTEMS
SAMPLE EVALUATION QUESTIONS

Littlejohns et al (2003) Evaluation of an Integrated Hospital Information System in South Africa: 10 evaluation projects:

1. Are training, change management and support optimal?
2. Is the reliability of the system (including peripherals, network, hardware and software) optimal?
3. Assessing the project management.
4. Does the system improve the communication of patient information between healthcare facilities?
5. Is data protection adequate?
6. Assessing the quality and actual use of decision-making information to support clinicians, hospital management, provincial health executives and the public.
7. Are patient administration processes more standardized and efficient?
8. Has revenue collection improved?
9. Is information being used for audit or research?
10. Are costs per unit service reduced?

Heathfield et al (1997) Evaluating Large Scale Health Information Systems: From Practice Toward Theory: Evaluation of 2 NHS projects, an Electronic Patient Record Project and an Integrated Clinical Workstation (ICWS); 6 major evaluation questions identified:

1. What is the impact of the technology on clinical management at 3 levels: individual patient care, management of services, and resource management?
2. What is the impact on the roles, the organization of work and work satisfaction of staff? What is the experience of working and living at the implementation sites?
3. Can the costs and benefits of such developments/technologies be valued?
4. Patient record systems and technologies: How useful and useable are they?
5. What is the relationship between electronic and paper records for the EPR/ICWS sites in respect of: availability of data, integrity, compliance with standards, volume of paper generated and reduction in clerical activity?
6. What is the relationship between the technology and the general management of the trust?

Anderson JG, Aydin CE, Jay SJ. Evaluating Health Care Information Systems: Methods and Applications. Thousand Oaks, California: Sage Publications, 1994.

Adapted from Table 1.1, page 13-14.

Evaluation Questions and Suggested Methods	
Evaluation Question	*Suggested Methods*
1. Does the system work as designed?	Qualitative (interviews, observation, documents) Survey Laboratory/quasi-experiment Cost-benefit analysis Clinical information processing scenarios
2. Is the system used as anticipated?	Qualitative (interviews, observation, documents) Survey Quasi-experiment Cohort/time series study Post-intervention study
3. Does the system produce the desired results?	Qualitative (interviews, observation, documents) Survey Laboratory/quasi-experiment/simulation Cohort/time series study Post-intervention study Cost-benefit analysis
4. Does the system work better than the procedures it replaced?	Qualitative (interviews, observation, documents) Survey Quasi-experiment Simulation Cohort/time series study Cost-benefit analysis
5. Is the system cost-effective?	Cost-benefit analysis
6. How well have individuals been trained to use the system?	Qualitative (interviews, observation, documents) Survey Cohort/time series study

(cont'd)

Evaluation Questions and Suggested Methods	
Evaluation Question	*Suggested Methods*
7. What are the anticipated long-term impacts on how departments interact?	Cohort/time series study Network analysis
8. What are the long-term effects on delivery of medical care?	Qualitative (interviews, observation, documents) Survey Quasi-experiment Cost-benefit
9. Will the system have an impact on control in the organization?	Qualitative (interviews, observation, documents) Survey Network analysis Cost-benefit analysis
10. To what extent do impacts depend on practice setting?	Qualitative (interviews, observation, documents) Survey Quasi-experiment

Amatayakul M. *Critical Success Factors*. Focus on Evaluating CPR Systems. Health Care Management Technology, May 2000, 14-17

Adapted from section on Steps to Evaluating CPR Systems, p.15.

(1) Does the system support the mission of the organization and provide for continuity of care?

(2) Does the system enable the business goals of the organization?

(3) Does the CPR contribute to improved patient care and not just administrative efficiencies?

(4) Are end-users engaged in evaluating present systems and creating a vision for the CPR? Do the end-users have an easy way to communicate issues and ideas to management and information systems services?

(5) Is there a vision of an information infrastructure to support continuous clinical service?

(6) Have knowledge requirements been assessed and new approaches to data management taken?

(7) Do present systems support the data content requirements of the new transaction standards?

(8) What planning has been done to support additional uniform data standards?

(9) Do users see the value in using the system?

(10) Does management understand the nature and timeframe for return on investment?

(11) Have resources been assigned to continuously monitor benefits realization?

(12) Have the goals of service effectiveness, operational efficiency, and informational empowerment been achieved?

NHS PROBE 2001. Evaluation Framework for NHS Electronic Patient Record and Electronic Health Record. Evaluation Questions posed in 3 time frames and along 5 dimensions: strategy, operational, technical, financial and human.

Sample questions extracted from Appendix C: Table Showing Suggested Focus of Evaluations, p 21-27.

TIMING OF EVALUATION	SUGGESTED FOCUS	SAMPLE QUESTIONS
Pre-Implementation Review	**Strategic**	Are organizations ready for EPR/EHR implementation? Are stakeholders ready? Does the investment 'fit' with other strategies: • LIS • HimP • Clinical Governance?
	Operational	Are business processes being reviewed in preparation for EPR/EHR?
	Financial	Is the investment affordable? Have the risks been assessed and are they affordable?
	Human	Are individuals and teams ready for EPR? Are the training and support programs in place?
	Technical	Are suitable project management structures in place? Is the IT infrastructure capable of supporting EPR? Are the necessary security policies in place? Are contract management teams in place?

TIMING OF EVALUATION	SUGGESTED FOCUS	SAMPLE QUESTIONS
Implementation Review This is most important early in the project lifecycle, as technical problems are likely to alienate users. Therefore, it should be a strong focus of post-implementation reviews rather than post operational evaluations.	**Technical**	Has the IM&T Strategy been effective? Has it delivered the information systems that meet the information requirements of users? Has the EPH/EHR project deployed technology in the most effective way? Is the system flexible enough to cope with changing requirements? Is the EPR/EHR secure? Was the EPR/EHR procurement defensible? Are the project management, implementation and contract management structures effective? Is there efficient use of IM&T resources? Could IM&T resources be deployed more efficiently? Has testing been effective? Is there evidence of faults that could have been eliminated by further testing? Are the IM&T support mechanisms effective?
Implementation Review **Or** **Operational Evaluation**	**Financial**	The business case. Was the business case realistic? Have the quantifiable costs and benefits been realized? Were the risks understood? Are they being managed? How was the EPR/EHR affected by the financial position of the stakeholder organizations and the community as a whole? How has the financial context changed through the life of EPR/EHR? How has the EPR/EHR development affected benchmarked positions (reference costs, cost per bed day, cost per FCE etc)?

TIMING OF EVALUATION	SUGGESTED FOCUS	SAMPLE QUESTIONS
Implementation Review Or Operational Evaluation	**Strategic** (Likely to be more suited to Post Operational Evaluation because of the time required to assess the degree of strategic change)	Has EPR/EHR development delivered the strategic change predicted in LIS and the business case? Has EPR/EHR contributed positively to the implementation of the Himp and Clinical Governance? Has EPR/EHR enabled the stakeholders to address changing strategic priorities (such as the NHS Plan) since the EPR/EHRs' inception? What are the strategic dependencies between the EPR/EHR project and other LIS projects? How has the EPR/EHR development contributed to other dependent projects within the LIS?

Implementation Review Or Operational Evaluation (cont'd)	**Operational**	Is there evidence of clinical benefits in areas such as: • The avoidance of errors and adverse effects • Improved patient outcomes • Benefits from faster interventions and improved communications • Electronic prescribing and formulary management • Enhanced risk management • Discharge planning • Clinic scheduling Has the introduction of care pathways and protocols delivered benefits for patients and clinicians? Has the clinical time been saved through the introduction of more efficient administration and faster access to records? Has there been a reduction in paper, and reduced use of the paper records? Do clinicians use the EPR/EHR?

TIMING OF EVALUATION	SUGGESTED FOCUS	SAMPLE QUESTIONS
Implementation Review **Or** **Operational Evaluation**	**Operational** (Con't)	Does the EPR/EHR deliver the information required to support clinical governance and clinical audit? Has data quality improved?
	Human Human factors are important early in the implementation process, and to ensure that the system is used as intended and also that the user interface is acceptable Stakeholder groups: • Clinical users • Patients • Carers • Managers	What has been the impact of the project and the EPR/EHR on individuals and the way they provide or receive care? Has EPR/EHR delivered the benefits that they personally expected? Has the EPR/EHR improved the patient and carer experience of the NHS? Is the system or information used as often as they expected? Have person-to-person communications improved? Specifically, have patient - clinician and clinician - clinician communications improved? Have business processes changed? Is there a learning and personal development culture? Are individuals supported to enable them to optimize their use of EPR/EHR? Are staff aware of their responsibilities within the benefits realization plan? Are staff able to use EPR/EHR to react to changing internal and external priorities and demands?

Kaplan B et al. Towards An Informatics Research Agenda: Key People and Organizational Issues. Journal of the American Medical Informatics Association, 2001, 8(3) 235-241.

EXCERPTS FROM TABLE 1, PAGE 236
Research Agenda Model: Key People and Organizational Issues – Sample Questions at Different Levels

SOCIAL SCIENCE DISCIPLINE LEVEL (LOW AGGREGATION TO HIGH AGGREGATION)			
INDIVIDUAL/COGNITIVE PSYCHOLOGY	**WORKGROUP/SOCIAL PSYCHOLOGY**	**ORGANIZATION/SOCIOLOGY**	**CULTURE/CULTURAL ANTHROPOLOGICAL**
• What affects information-seeking behaviour and how information is used?	• How do rapid communication and changing roles of health care providers affect professional relationships?	• How does widespread availability of health information affect relationships and roles between providers and patients or consumers?	• How should information be tailored to suit individuals from different cultural groups?
• How do different information sources influence health care decisions and outcomes? • What information and information designs are effective for different individuals?	• How does widespread availability of health information affect the patient role and patient decision-making?		• How does one's culture affect one's use of IT?

SOCIAL SCIENCE DISCIPLINE LEVEL (LOW AGGREGATION TO HIGH AGGREGATION) – CON'T			
INDIVIDUAL/COGNITIVE PSYCHOLOGY	**WORKGROUP/SOCIAL PSYCHOLOGY**	**ORGANIZATION/SOCIOLOGY**	**CULTURE/CULTURAL ANTHROPOLOGICAL**
• How can multiple sources and formats of individual data be integrated or aggregated?	• How do auditing and monitoring of care affect professional identity and cohesion? • How does the potential for distributed information and workflow affect how processes are organized and carried out?	• What would constitute an acceptable lifetime health record for each individual? Acceptable to whom? • How do linkages through IT affect organizational identity and integrity?	• How can data be integrated and aggregated across organizations to obtain indicators and guidelines for improving care? • How will clinicians and patients at an institution react to global indicators and guidelines?

APPENDIX B
EVALUATION of COMPLEX HEALTH INFORMATION SYSTEMS
SAMPLE INDICATORS

van der Loo et al (1995) Evaluation of automated information systems in health care: an approach to classifying evaluative studies.

Effect measures in reviewed studies included:

(1) costs
(2) time changes for personnel (for example faster diagnosing)
(3) time changes for personnel (for example waiting times)
(4) time changes in logistical processes (for example, retrieval of images)
(5) database use
(6) use of medical tests
(7) the performance of the user (for example compliance with on-line documentation requirements)
(8) performance of the system (for example the number of correctly indicated patients with hypertension)
(9) patient outcomes (ength of stay, quality of life)
(10) job satisfaction
(11) patient satisfaction

Bates et al (1999) The Impact of Computerized Physician Order Entry on Medication Error Prevention

Types of medication errors measured included:

(1) dose errors
(2) frequency errors
(3) error routes
(4) substitution errors
(5) allergies
(6) non-missed dose medication error (major variable of interest)

Darbyshire P*. User-Friendliness of Computerized Information Systems*. Computers in Nursing. March/April 2000. 93-99.

Indicators of user-friendliness for nurse clinicians using a computerized information system included:

(1) ease of access (uncomplicated password function)
(2) availability of terminals
(3) clarity and navigatability of computer screens
(4) use of intuitive icons and graphics
(5) availability of on-line help
(6) availability of on-screen prompts and reminders
(7) ease of printing clinical documentation when required
(8) speed and responsiveness of the system

Keshavjee K, Troyen S, Holbrook AM, VanderMolen D (2001) *Measuring the success of electronic medical record implementation using electronic and survey data*.

Measures at pre-implementation, and 6 and 18 months post implementation.

Staff related administrative measures:

(1) time taken for chart pulls (for day visits, filing lab results and consult notes)
(2) time spent in writing in the chart

Physician related clinical measures:

(1) time spent writing in the chart
(2) time spent writing prescriptions
(3) time to review consult notes
(4) perception of length of day worked (number of hours/day worked)
(5) perception of the quality of the chart
(6) number of patients seen per day
(7) perception of volume of work

Krall MA. *Acceptance and Performance by Clinicians Using an Ambulatory Electronic Medical Record in a HMO*. AMIA, 1995, 708-711.

Project was evaluated using pre-implementation and 2 and 4-6 months post implementation user surveys, management engineering studies and monitoring of clinician productivity.

Pre-implementation Survey:

(1) pre-existing computer experience and attitudes
(2) preferred learning methods

Post Implementation Survey

(1) perceived efficiencies of new system compared to the previous one
(2) suggestions regarding system improvements

Management Engineering Studies pre and post implementation:

(1) clinician time to complete tasks (chart review, exam and treat, orders and diagnosis, and charting)

Clinical productivity measures:

(1) visits per hour per clinician, pre and post implementation

Protti D, Peel V*. Critical Success Factors for Evolving a Hospital Toward an Electronic Patient Record System: A Case Study of Two Different Sites*. Journal of Healthcare Information Management; 1998, 12(4), 29-37

Critical Success Factors include:

(1) a clinical, not just medical focus
(2) routine clinical use of the systems
(3) executive leadership and sound management
(4) nurturing of a new culture
(5) stability and a mature management-clinical partnership

Tangible and intangible benefits include:

(1) ease of location of clinical information needed to care for patients
(2) reduction in unnecessary or duplicate testing
(3) waiting times for treatment reduced
(4) improved communication between disciplines

Delone WH, McLean ER*. Informations Systems Success: The Quest for the Dependent Variable*. Information Systems Research; 1992, 3(1), 60-95.

Empirical Measures of Information Quality (summarized from the review of 9 studies presented in Table 2, page 67)

(1) Accuracy
(2) Timeliness
(3) Reliability
(4) Completeness
(5) Format
(6) Relevance to decisions
(7) Understandability

Delone WH, McLean ER. The Delone and McLean Model of information System Success: A Ten Year Update. Journal of Management Information Systems; 2003, 19(4), 9-30.

E-Commerce Success Metrics (Table 1, page 26)

Systems quality:

(1) Adaptability
(2) Availability
(3) Reliability
(4) Response time
(5) Usability

Information quality:

(1) Completeness
(2) Ease of understanding
(3) Personalization
(4) Relevance
(5) Security

Service quality:

(1) Assurance
(2) Empathy
(3) Responsiveness

Use:

(1) Nature of use
(2) Navigation patterns
(3) Number of site visits
(4) Number of transactions executed

User satisfaction:

(1) Repeat purchases
(2) Repeat visits
(3) User surveys

Net benefits:

(1) Cost savings
(2) Expanded markets
(3) Incremental additional sales
(4) Reduced search costs
(5) Time savings

Kaplan B, Lundsgaarde HP. *Toward an Evaluation of an Integrated Clinical Imaging System: Identifying Clinical Benefits*. Methods of Information in Medicine; 1996, 35, 221-9.

Benefits identified by physicians as a result of introducing a PACS system include:

Patient Care Benefits:

(1) improved clinical communication and decision making
(2) care becomes more patient-based
(3) reduction in the number of procedures and patient risk
(4) improvement in medical record keeping

Educational Benefits:

(1) improved communication between teaching physicians and residents
(2) provision of "real" patient learning experience (access to more complete patient information)
(3) improved student supervision

Productivity and Cost Reduction Benefits

(1) elimination of time gaps between the production of images and written reports
(2) convenience in terms of writing, storing and reviewing notes with images during or immediately after a procedure
(3) continuous availability of images with patient records

Bates D, Pappius E et al*. Using Information Systems to Measure and Improve Quality*. International Journal of Medical Informatics; 1999, 53, 115-124.

Measures of quality that were extracted from a hospital information system include:

(1) use of unnecessary laboratory testing
(2) speed of report of abnormalities in results to providers
(3) prevention and detection of adverse drug events
(4) clinical department's selection of measures for efficiency, critical variances and sentinel events

Chin HL, McClure P. *Evaluating a Comprehensive Outpatient Clinical Information System: A Case Study and Model for System Evaluation*; AMIA, 1995, 717-721.

Indicators of a Successful System Implementation, as excepted from Table 1, page 718:

(1) high user acceptance
(2) productivity of clinicians
(3) high patient acceptance
(4) high use of the system
(5) technical adequacy (good performance, stability of the product, no loss of data)
(6) flexible, modifiable and expandable system

Gadd CS, Penrod LE. Assessing Physician Attitudes Regarding Use of an Outpatient EMR: A Longitudinal, Multi-Practice Study; AMIA, 2001, 194-198.

Physician concerns, measured pre and post implementation of an EMR, as excepted from Table 2, page 197:

(1) time required to enter orders for tests or medications
(2) time required for documentation, such as progress notes
(3) rapport established between physician and patient during the visit
(4) patient privacy
(5) physician autonomy
(6) patient's satisfaction with the quality of care they receive
(7) the overall quality of health care that you give your patients

Abdelhak M. Health Information Management of a Strategic Resource. Philadelphia, Pa: W.B. Saunders Company, as summarized in F Hawkins. Evaluation of Clinical Documentation Before and After EMR Implementation; IT Health Care Strategist, 200, 2(12), 8-11.

General Medical Records Documentation requirements:

- Name/medical record number on each page
- Summary sheet/problem list complete
- Current and past medications entered on the medication sheet
- All entries dated
- Presence or absence of allergies is documented in a prominent and uniform location

- Every patient visit includes documentation of:
  - chief complaint/purpose of visit
  - history and physical consistent with chief complaint
  - diagnosis or impression
  - treatment
  - patient disposition, referral, instructions; and
  - signature of practitioner

- Immunization record includes:
  - date
  - vaccine manufacturer name and lot number
  - test results filed in sequential order
  - all test results initiated and dated by practitioner; and
  - informed consent present

- Pre-anesthesia evaluation:
  - is recorded prior to surgery
  - includes review of patient's medical history
  - includes previous anesthetic experiences
  - includes current medications and
  - includes date and signature of anesthesiologist

General Medical Records Documentation requirements (Con't):

- Anesthesia record includes documentation of:
  - time-based monitoring of vital signs and level of consciousness
  - status of surgical dressing
  - status of tubes; and
  - date and signature of discharging practitioner

- The operative report includes documentation of:
  - preoperative diagnosis
  - postoperative diagnosis
  - findings
  - technique used
  - specimens removed
  - primary surgeon and assistants
  - date and signature of surgeon; and
  - documentation of postoperative instructions; and

- The pathology report is filed in the medical record

Birkmeyer CM, Bates DW, Birkmeyer JD. *Will Electronic Order Entry Reduce Health Care Costs?* Effective Clinical Practice; March/April 2002, 5(2), 67-74.

Potential pre and post implementation measures of cost include:

(1) patient bed-days per year
(2) costs of adverse drug events
(3) costs of serious medication errors
(4) costs of unnecessary tests
(5) use of lower cost medications as substitutes

Wager KA, Ornstein SM, Jenkins RG. *Perceived Value of Computer-Based Patient Records Among Clinician Users*; M.D. Computing, 1997, 14(5), 344-340.

Perceived advantages of CPRs identified by 44 physician practices using the same CPR system:

(1) improved documentation for patient care
(2) quality of the patient record
(3) access to the patient record
(4) improved documentation for prevention services
(5) improved documentation for quality improvement
(6) ease of use
(7) security of patient record
(8) improved efficiency
(9) administrative cost savings

Doran B, DePalma JA. *Plan to Assess the Value of a Computerized Documentation System*: Adaption for an Emergency Department; Top Emerg Med, 1996, 18(1), 63-73.

Pre-Implementation assessment of ER documentation, as extracted from Table 1, page 65

VARIABLE	INDICATOR	HOW MEASURED
Accuracy	Injection sites	Chart audit/checklist: • Site • Abbreviation
	Intake and output	Chart audit/checklist: • Totals • Correct math • Percent missing data
	Vital signs	Check original order and chart for transcription errors
Quality	Standard by diagnosis • Critical elements	Compare charting with checklist of critical charting elements for common diagnoses. • Percent items charted • Consistency among nurses Compare checklist with critical charting elements from standard of care: • Percent items charted • Consistency among nurses
Safety	Types of medication errors	Risk management data quarterly reports – totals
	Medication transcription errors	Check original order and medication record for transcription errors.
Physician satisfaction	Satisfaction with critical elements of documentation; • Availability of data	Create survey with items for physicians' response: • Laboratory data • Intake and output • Medication data

VARIABLE	INDICATOR	HOW MEASURED
Physician satisfaction (Con't)		• Weights • Nursing assessment • Summary data
	Satisfaction with critical elements of documentation: • Availability of chart in general	Availability of chart Location of chart on unit
	Satisfaction with critical elements of documentation: • Accuracy/completeness	Intake and output New information Nursing assessment information in general

***Computerized Provider Order Entry Syste*ms. Evaluation. Health Devices; 2001, 30 (9-10), 323-359.**

Evaluation Criteria for CPOE include:

User Interface:	order entry order processing order output
Patient Safeguards:	basic safety alerts and safeguards additional safety features
Order Monitoring	
Knowledge Base	
Data Management:	System access Integration with Ancillary Information Systems Data Access Network Degradation Management

(Note: this publication also contains very detailed indicators for the above listed criteria)

Sittig DF, Kuperman GJ, Fiskio J. Evaluating Physician Satisfaction Regarding User Interactions with an Electronic Medical Record System; AMIA, 1999, 400-404.

The authors used the QUIS (Questionnaire For User Interaction Satisfaction) developed by Chin et al at the University of Maryland to measure user interaction satisfaction with an EMR in routine clinical use. The short form of the QUIS is divided into 5 sections of 4 questions each. Variables assessed, using a 9 point scale, include:

(1) overall user reactions
(2) screen design and layout
(3) terminology and system messages
(4) learning
(5) system capabilities

Mitchell E, Sullivan F. *A Descriptive Feast But Evaluative Famine: Systematic Review of Published Articles on Primary Care Computing during 1980-1997*; BMJ, 2001, 322, 279-282.

61 studies examined the effects of computers on practitioners' performance, 17 evaluated their impact on patient outcome and 20 studied practitioners' or patients' attitudes.

Practitioners' Performance:

(1) immunization rates
(2) performance of preventive tasks
(3) content of consultation
(4) disease management
(5) prescribing

Patient Outcomes:

(1) changes in diastolic blood pressure
(2) impact on anticoagulant management
(3) service utilization
(4) location of service utilization (hospital versus community)
(5) rates of non attendance at scheduled appointments
(6) patient satisfaction

Practioners's and Patients' Attitudes:

(1) attitudes about use of computers in practice
(2) perceptions regarding record accuracy and accessibility
(3) privacy
(4) doctor-patient relationship
(5) cost
(6) time
(7) training