Chapter 2

Benefits Evaluation Framework

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2.1 Introduction

The Benefits Evaluation (BE) Framework was published in 2006 as the result of a collective effort between Canada Health Infoway (Infoway) and a group of health informaticians. Infoway is an independent not-for-profit corporation with the mission to accelerate the development, adoption and effective use of digital health innovations in Canada. The health informaticians were a group of researchers and practitioners known for their work in health information technology (HIT) and health systems data analysis. These individuals were engaged by Infoway to be members of an expert advisory panel providing input to the pan-Canadian benefits evaluation program being established by Infoway at the time. The expert advisory panel consisted of David Bates, Francis Lau, Nikki Shaw, Robyn Tamblyn, Richard Scott, Michael Wolfson, Anne McFarlane and Doreen Neville.

At the time in Canada, the increased focus on evaluation of eHealth, both nationally and in the provinces and territories, reflected similar interest internationally. There was an increasing demand for evidence-informed investments, for information to drive optimization, and for accountability at project completion (Hagens, Zelmer, Frazer, Gheorghiu, & Leaver, 2015). The expert advisory panel recognized that a framework was a necessary step to convert that interest into focused action and results.

The intent of the BE Framework was to provide a high-level conceptual scheme to guide eHealth evaluation efforts to be undertaken by the respective jurisdictions and investment programs in Canada. An initial draft of the BE Framework was produced by Francis Lau, Simon Hagens, and Sarah Muttitt in early 2005. It was then reviewed by the expert panel members for feedback. A revised version of the framework was produced in fall of 2005, and published

in *Healthcare Quarterly* in 2007 (Lau, Hagens, & Muttitt, 2007). Supporting the BE Framework, the expert panel also led the development of a set of indicator guides for specific technologies and some complementary tools to allow broad application of the framework. Since its publication, the BE Framework has been applied and adapted by different jurisdictions, organizations and groups to guide eHealth evaluation initiatives across Canada and elsewhere.

This chapter describes the conceptual foundations of the BE Framework and the six dimensions that made up the framework. We then review the use of this framework over the years and its implications on eHealth evaluation for healthcare organizations.

2.2 Conceptual Foundations

The BE Framework is based on earlier work by DeLone and McLean (1992, 2003) in measuring the success of information systems (IS) in different settings, the systematic review by van der Meijden, Tange, Troost, and Hasman (2003) on the determinants of success in inpatient clinical information systems (CIS), and the synthesis of evaluation findings from published systematic reviews in health information systems (HIS) by Lau (2006) and Lau, Kuziemsky, Price, and Gardner (2010). These published works are summarized below.

2.2.1 Information Systems Success Model

The original IS Success Model published by DeLone and McLean in 1992 was derived from an analysis of 180 conceptual and empirical IS studies in different field and laboratory settings. The original model has six dimensions of IS success defined as system quality, information quality, use, user satisfaction, individual impact, and organizational impact (Figure 2.1). Each of these dimensions represents a distinct construct of "success" that can be examined by a number of quantitative or qualitative measures. Examples of these measures for the six IS success dimensions are listed as follows:

- *System quality* – ease of use; convenience of access; system accuracy and flexibility; response time
- *Information quality* – accuracy; reliability; relevance; usefulness; understandability; readability
- *Use* – amount/duration of use; number of inquiries; connection time; number of records accessed
- *User satisfaction* – overall satisfaction; enjoyment; software and decision-making satisfaction

- *Individual impact* – accurate interpretation; decision effectiveness, confidence and quality

- *Organizational impact* – staff and cost reductions; productivity gains; increased revenues and sales

In 2003, DeLone and McLean updated the IS Success Model based on empirical findings from another 285 journal papers and conference proceedings published between 1992 and 2002 that validated, examined or cited the original model. In the updated model a service quality dimension was added, and the individual and organizational impact dimensions were combined as a single construct called net benefits (Figure 2.2). The addition of service quality reflected the need for organizations to recognize the provision of IS service support beyond the technology as a determinant of IS success. Examples of *service quality measures* are *staff reliability, empathy and responsiveness*. On the other hand, the net benefits dimension was chosen to simplify the otherwise increasing number and type of impacts being reported such as group, industry and societal impacts. Also the inclusion of the word "net" in net benefits was intentional, as it emphasized the overall need to achieve positive impacts that outweigh any disadvantages in order for the IS to be considered successful.

The IS Success Model by DeLone and McLean is one of the most widely cited conceptual models that describe the success of IS as a multidimensional construct. It is also one of the few models that have been empirically validated in numerous independent laboratory and field evaluation studies across different educational, business and healthcare settings.

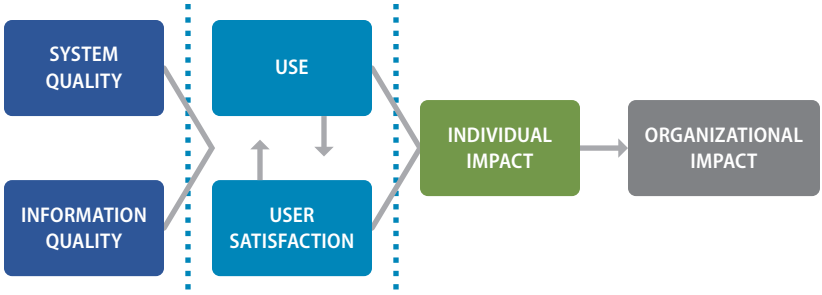

Figure 2.1. IS success model.

Note. From "Information systems success: The quest for the dependent variable," by W. H. DeLone and E. R. McLean, 1992, *Information Systems Research, 3*(1), p. 87. Copyright 1992 by INFORMS, http://www.informs.org. Reprinted with permission.

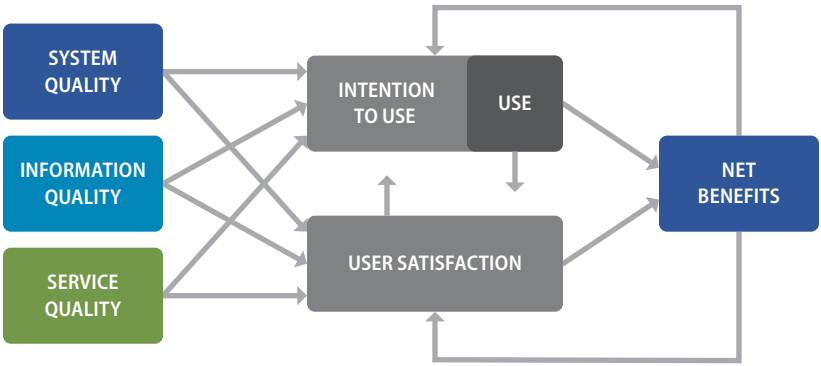

Figure 2.2. Updated IS success model.

Note. From "The DeLone and McLean model of information systems success: A ten-year update," by W. H. DeLone and E. R. McLean, 2003, *Journal of Management Information Systems, 19*(4), p. 24. Copyright 2003 by Taylor & Francis. Reprinted with permission.

2.2.2 Clinical Information Systems Success Model

Van der Meijden et al. (2003) conducted a literature review on evaluation studies published from 1991 to 2001 that identified attributes used to examine the success of inpatient clinical information systems (CIS). The review used the IS Success Model developed by DeLone and McLean as the framework to determine whether it could correctly categorize the reported attributes from the evaluation studies. In total, 33 studies describing 29 different CIS were included in the review, and 50 attributes identified from these studies were mapped to the six IS success dimensions (Table 2.1). In addition, 16 attributes related to system development, implementation, and organizational aspects were identified as contingent factors outside of the six dimensions in the IS Success Model (Table 2.2).

Table 2.1

Attributes of CIS Success Factors

System Quality Attributes	Information Quality Attributes	Usage Attributes	User Satisfaction Attributes	Individual Impact Attributes	Organizational Impact Attributes
• Ease of use – (record keeping time), • Response time, • Time savings, • Intrinsic features creating extra work, • Perceived ease of use, • Usability, • Availability, • Ease of learning, • Rigidity of system – (built-in rules), • Reliability, • Security, • Easy access to help, • Data accuracy	• Completeness, • Accuracy of data, • Legibility, • Timeliness, • Perceived usefulness, • Availability, • Comprehensive, • Consistency, • Reliability, • Format	• Number of entries, • Frequency of use, • Duration of use, • Self-reported usage, • Location of data entry, • Frequency of use of specific functions	• User satisfaction, • Attitude, • User friendliness, • Expectations, • Competence in computers	• Changed clinical work patterns, • Direct benefits, • Changed documentation habits – (more administrative tasks, time of day for documenting, documentation frequency), • Information use – (information recall, accurate interpretation, integration of information / overview, information awareness), • Efficiency and effectiveness of work, • Job satisfaction	• Communication and collaboration, • Impact on patient care, • Costs – (time savings, reduction of staff, number of procedures reduced)

Note. From "Determinants of success of clinical information systems: A literature review," by M. J. van der Meijden, H. J. Tange, J. Troost, and A. Hasman, 2003, *Journal of the American Medical Informatics Association, 10*(3), p. 239. Copyright 2003 by Oxford University Press, on behalf of the American Medical Informatics Association. Adapted with permission.

Table 2.2

Attributes of Contingent Factors

System Development Attributes	Implementation Attributes	Organizational Aspects Attributes
• User involvement • Redesign work practices • Reconstruction of content / format • Technical limitations	• Communication (frequency, two way) • Training • Priorities chosen • Technical support • User involvement	• Organizational culture – (control and decision-making, management support, professional values, collaboration / communication) • Support and maintenance • Champions • Rewards

Note. From "Determinants of success of clinical information systems: A literature review," by M.J. van der Meijden, H. J. Tange, J. Troost, and A. Hasman, 2003, *Journal of the American Medical Informatics Association, 10*(3), p. 241. Copyright by Oxford University Press, on behalf of the American Medical Informatics Association. Adapted with permission.

Since its publication in 2003, the CIS Success Model by van der Meijden and colleagues (2003) has been widely cited and applied in eHealth evaluation studies. The CIS Success Model can be considered an extension of the original IS Success Model in that it recognizes the influence and importance of contingent factors related to the system development, implementation and organizational aspects that were not included in the original model.

2.2.3 Synthesis of Health Information System Reviews

Lau (2006) examined 28 systematic reviews of health information system (HIS) evaluation studies published between 1996 and 2005. From an initial synthesis on 21 of the published reviews pertaining to clinical information systems/tools and telehealth/telemedicine evaluation studies, Lau identified 60 empirical evaluation measures in 20 distinct categories of success factors based on the six IS success dimensions in the revised DeLone and MacLean model (i.e., system, information and service quality, use and user satisfaction, and net benefits). These empirical evaluation measures were reconciled with the success measures reported in the original and revised DeLone and MacLean models, as well as the attributes identified in the van der Meijden et al. model. Additional findings from the Lau review that were supplementary to the BE Framework included the clinical domains, study designs and evaluation measures used in the evaluation studies. These findings provided an initial empirical evidence base for the potential application of the BE Framework dimensions, categories and measures (Lau, 2006). Selected findings for 14 of the initial 21 systematic reviews examined are shown in Table 2.3. See also the separate additional references section for Table 2.3.

Table 2.3
Summary of 14 Systematic Review Articles on HIS Field Evaluation Studies

Authors	Topic	Design	Evaluation Metrics
Ammenwerth and de Keizer (2004)	Health info systems, evaluation	1,035 studies	Journal, type, location, method, focus
Balas et al. (1998)	Clinical info systems	98 RCT	Process and outcome of care
Balas et al. (1996)	Diabetes management	15 CT	48 outcome measures reported
Cramer et al. (2003)	Computerized health evidence delivery	57 RCT, 10 SR	Process of care, patient health, others
Delpierre et al. (2004)	Patient record systems	26 studies	Practice, quality of care, satisfaction
Garg et al. (2005)	CDSS	100 CT	Performance and outcome
Kaushal et al. (2003)	CPOE, CDSS medication safety	12 trials	Behaviours, med errors, adverse events
Kawamoto et al. (2005)	CDSS	70 RCT	Improved clinical practice
Mitchell and Sullivan (2001)	CDSS in primary care	89 CT, B/A	Performance and outcomes
Montgomery and Fahey (1998)	Hypertension management	7 RCT	Performance, improved blood pressure
Sullivan and Mitchell (1995)	Computerized primary care consultation	30 studies	Consult time, preventions, satisfaction
van der Loos et al. (1995)	Health information systems in diffusion	108 studies	Structure, process, outcome measures
van der Meijden et al. (2003)	Inpatient clinical info systems	33 studies	Quality, use and impact
Walton et al. (1999)	Optimum drug dosage	18 trials	Effect size, relative % difference

Legend: CDSS – clinical decision support system; RCT – randomized control trial; CT – controlled trial; SR – systematic review; B/A – before/after; TS – time series; EMR – electronic medical record; DS – decision support

Note. From "Increasing the rigor of health information system studies through systematic reviews," by F. Lau, 2006, a presentation to *11th International Symposium on Health Information Management Research (iSHIMR)*, Halifax, Nova Scotia, Canada.

2.3 Benefits Evaluation Framework Dimensions

The BE Framework is based on all six dimensions of the revised DeLone and MacLean IS Success Model, which are system, information and service quality, use and user satisfaction, and net benefits. A total of 20 categories and 60 subcategories of evaluation measures are defined in the BE Framework. They are based on the measures identified in the van der Meijden et al. (2003) CIS Success Model and the Lau et al. (2010) HIS review synthesis. In the BE Framework, the net benefits are further grouped into three subcategories of care quality, access and productivity. These subcategories are from the original benefits measure-

ment framework defined by Infoway to determine the impact of digital health broadly on national healthcare renewal priorities (Infoway, 2005).

When creating the BE Framework, Infoway recognized the importance of organizational and contextual factors on the adoption and impact of eHealth systems. However, these factors were considered out-of-scope at the time in order to reduce the complexity of the framework. The scope was also tailored to increase its acceptance by stakeholder organizations, as many of the eHealth project teams who would be overseeing evaluation were not well positioned to investigate and report on the broader issues. The BE Framework is shown in Figure 2.3. Note that there are other measures in the IS and CIS success models that are not in the BE Framework. They were excluded for such pragmatic reasons as the perceived subjective nature of the data and the difficulty in their collection.

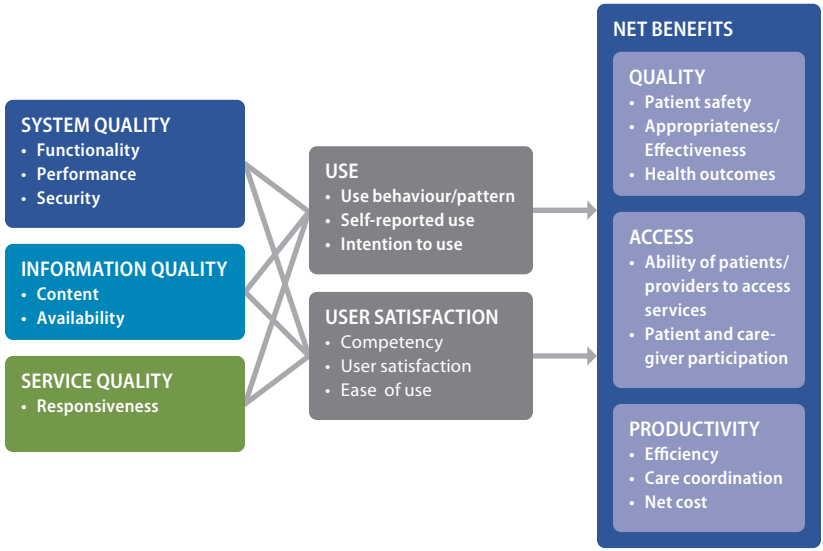

Figure 2.3. Infoway benefits evaluation (BE) framework.

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2.3.1 Health Information Technology Quality

There are three HIT quality dimensions, namely system, information, and service.

> *System quality* refers to the technical aspects of the HIT and has three categories of measures on system functionality, performance and security. Functionality covers the type and level of HIT features present such as order entry with decision support for reminders and alerts. Performance covers the technical behaviour of the HIT in terms of its accessibility, reliability and response time. Security

covers the ability to protect the integrity and use of the data captured, and to ensure only authorized access to the HIT.

Information quality refers to the characteristics of the data in the system and has two categories on the quality of the content and its availability. Content covers the accuracy, reliability, completeness and comprehension of the data. Availability covers the timeliness of accessing the data when and where needed.

Service quality refers to HIT implementation, training and ongoing support by staff and has one category on responsiveness. Examples of responsiveness are the extent and adequacy of user training and technical support available. Not included are service empathy and assurance from the IS success model which were considered too subjective to evaluate at that time. Note that for each of the BE Framework dimensions and categories there are further breakdowns into subcategories and measures. See section 2.3.4 for a complete list of the defined HIT quality measures.

2.3.2 Use and User Satisfaction

The use dimension in the BE Framework has three categories which are usage behaviour and pattern, self-reported use, and intention to use. Usage behaviour and pattern cover actual HIT usage in terms of type, frequency, duration, location and flexibility. One example is the volume of medication orders entered by providers on the nursing units in a given time period. Self-reported use covers perceived HIT usage reported by users in terms of type, frequency, duration, location and flexibility. Intention to use is the proportion of and factors causing non-users of an implemented HIT to become active users of the system. The satisfaction dimension has three categories, namely competency, user satisfaction, and ease of use. Competency covers the knowledge, skills and experience of the users in the HIT. User satisfaction covers the extent to which the users feel gratified from using the HIT to accomplish their tasks. Ease of use covers the extent to which the users feel the HIT is both easy to learn and easy to use.

2.3.3 Net Benefits

The net benefits dimension has three categories of measures on care quality, access and productivity, respectively. Care quality has three subcategories: patient safety, appropriateness and effectiveness, and health outcomes. Patient safety includes adverse events, prevention, surveillance, and risk management. Appropriateness includes the adherence and compliance to benchmarks, policy or practice standards, and self-reported practices or practice profiles captured in the system. Effectiveness includes continuity of care with individuals or local/dispersed teams and referral of services. Health outcomes include short-term

clinical outcomes and longer-term change in the health status of patients attributable to HIT interventions.

Access has two subcategories that cover the ability of the patient to access care, which includes enabling access to care through technology (e.g., videoconferencing) and driving improvements in access (e.g., wait time information systems), and the extent of patient/caregiver participation in these services. Productivity has three subcategories: efficiency, care coordination, and net cost. Efficiency includes resource use, output and care continuity improvement, and health systems management capability. Care coordination includes care provision by teams and continuity of care across settings. Net cost includes monetary avoidance, reduction and saving.

2.3.4 Summary of Benefit Evaluation Measures

The BE Framework dimensions, categories, subcategories and measures are summarized in Table 2.4. Note that these are suggested measures only, and are not an exhaustive list of measures reported in the literature. Healthcare organizations may choose to adopt these measures or adapt and extend the list to include new measures to suit their needs.

Table 2.4
Summary of BE Measures

Dimension	Category	Subcategories and Definitions of Measures
System	Functionality	Type and level of features available (e.g., order entry and decision support)
	Performance	Accessibility (remote and availability), reliability (up/down time) and system response time
	Security	Type and level of features available
Information	Content	Accuracy, relevance, completeness and comprehension
	Availability	Timeliness, reliability and consistency of data when and where needed
Service	Responsiveness	Extent and adequacy of implementation, training and ongoing support available
Use	User behaviour and pattern	Type, frequency, duration, location and flexibility of actual usage
	Self-reported use	Type, frequency, duration, location and flexibility of perceived usage
	Intention to use	Reasons for current non-users to become users and proportion who do
Satisfaction	Competency	Knowledge, skills and experience of users in the HIS
	User satisfaction	Extent to which the users feel gratified from using the HIS
	Ease of use	User friendliness and learnability

Table 2.4
Summary of BE Measures

Dimension	Category	Subcategories and Definitions of Measures
Net benefits	Care Quality	Patient safety - preventable adverse events, near-misses and errors - surveillance in monitoring of specific populations for patterns and trends - reduction in patient risks and safety-related reportable adverse events
		• Patient safety a) preventable adverse events, near-misses and errors b) surveillance in monitoring of specific populations for patterns and trends c) reduction in patient risks and safety-related reportable adverse events
		• Appropriateness and effectiveness a) adherence and compliance with benchmark, policy or practice standards and guidelines b) self-reported practice or practice captured in the HIS c) immunization and testing and other relevant rates d) continuity of care, examples: • information, relational and management continuity • by individuals or multi-disciplinary or geographically dispersed teams • access to information and effectiveness of general practitioner and specialist referral
		• Health outcomes a) clinical outcomes b) change in health status attributable to eHealth interventions
	Access	• Ability of patients and providers to access services a) availability, diversity and consolidation of eHealth-enabled services b) timeliness, geographic, financial and cultural or linguistic c) removal of inequitable barriers (including affordability, acceptability and accommodation) • Patient and caregiver participation a) patients' self-management and access to their own information
	Productivity	• Efficiency a) provider resource use b) improvement short term outputs vs. inputs, and long term in care continuity c) improved health system management capability d) improved patient efficiency (e.g., more efficient scheduling of preoperative testing) e) non-monetary effects • Care coordination a) care provision by team b) continuity of care across continuum • Net cost a) monetary avoidance b) monetary reductions, actual/projected savings

Note. From "A proposed benefits evaluation framework for health information systems in Canada," by F. Lau, S. Hagens, and S. Muttitt, 2007, *Healthcare Quarterly, 10*(1), p. 115. Copyright 2007 by Longwoods™ Publishing Corp. Reprinted with permission.

2.4 Benefit Evaluation Framework Usage

Since its debut in 2006, the BE Framework has been applied, adapted and cited in different evaluation reports, reviews, studies and commentaries. In this section we describe the companion resources that were created along with the framework. Then we summarize evaluation studies conducted in Canada that applied, adapted and cited the framework, followed by studies from other countries. Last, we include an example of a survey tool that can be used to evaluate the adoption of eHealth systems.

2.4.1 Companion Resources

The BE Framework is helpful in describing factors that influence eHealth success. But there should also be guidance and resources in place to help practitioners apply the framework in specific field evaluation studies. Guidance can be in the form of suggested evaluation questions, methods, designs and measures that are appropriate for the type of eHealth system and adoption stage involved, as well as the logistics for collecting and analyzing the data needed in the study. Another form of guidance required relates to managing evaluation activities, from structuring stakeholder engagement and gaining buy-in, to finding skilled evaluators, overseeing studies, and communicating results. Resources can be in the form of sample evaluation study plans, data collection tools, best practices in eHealth evaluation, completed evaluation reports and published peer-reviewed evaluation studies. As part of the initial release of the BE Framework in 2006, Infoway commissioned leading experts to develop indicator guides and compiled a BE Indicators Technical Report (Infoway, 2006) and a System and Use Assessment (SUA) survey tool (Infoway, 2006) as two companion resources. These resources were developed in collaboration with the Infoway BE expert advisory panel, eight subject matter experts, and two consultant teams.

The 2006 BE Indicators Technical Report (Infoway, 2006) includes a detailed description of the BE Framework, suggested evaluation questions, indicators and measures for specific eHealth programs, criteria for selecting appropriate BE indicators, and examples of tools and methods used in completed evaluation studies. The report covers six program areas, which are diagnostic imaging, drug information systems, laboratory information systems, public health systems, interoperable Electronic Health Records (iEHRs) and telehealth. These were some of the core initial investment programs funded by Infoway where it was necessary to assess tangible benefits to the jurisdictions and healthcare organizations as co-funders of these programs. Version 2.0 of the BE Indicators Technical Report was released in 2012 with expanded content (Infoway, 2012). The report still covers six program areas but laboratory information system has been merged with interoperable EHR as one section, and electronic medical records (EMR) for physician/nurse practitioner offices has been added as a new section. In Version 2.0 there are many more examples of published evaluation studies including those from Canadian jurisdictions and healthcare organizations. A BE planning template has also been added to facilitate the creation of a

practical evaluation plan for any eHealth system, and provide some of the practical guidance on managing evaluation activities. Since the publication of Version 2.0, additional program indicator sets and tools have been developed for telepathology, consumer health solutions and ambulatory EMR.

The SUA survey tool was introduced in 2006 as a multipart semi-structured questionnaire to collect information from users on the quality of the eHealth system and its usage in the organization. The questionnaire has since been adopted as a standardized Infoway survey tool to collect comparable information on the quality and use of eHealth systems being evaluated in Canada (Infoway, 2012). The SUA survey tool is aligned with the HIT quality, use and satisfaction dimensions of the BE Framework in terms of the questions used. The current version of this survey tool has eight sections of questions and guidance on how to administer the survey and analyze the results for reporting. These sections are on overall user satisfaction, system quality, information quality, service quality, public health surveillance, system usage, other comments, and demographic information. The survey can be adapted or expanded to include specific questions tailored to a particular eHealth system, such as the perceived accuracy of the images from the diagnostic imaging system being evaluated (Infoway, 2012).

2.4.2 Benefit Evaluation Framework Usage in Canada

Over the years, the BE Framework has been applied in over 50 evaluation studies across Canada. As examples, Table 2.5 shows 13 Canadian evaluation studies conducted over the past six years. See also the separate additional references section for Table 2.5. Six of these studies were related to telehealth, covering such clinical areas as ophthalmology, oncology and chronic disease management (British Columbia Ministry of Health [MOH], 2011a; B.C. MOH, 2011b; Gartner Inc., 2013; Praxia Information Intelligence & Gartner, Inc., 2010; Ernst & Young, 2014; Newfoundland and Labrador Centre for Health Information [NLCHI], 2010). Two studies covered drug information systems (Deloitte, 2010; Gartner Inc., 2013). Two studies covered diagnostic imaging systems (Gartner Inc., 2013; Hagens et al., 2009a). Two studies were on EMR systems for ambulatory and community care settings, respectively (PricewaterhouseCoopers [PWC], 2013; MOH, 2014). There was also one study each on vaccine inventory management (B.C. MOH, 2013), electronic occurrence reporting for patient safety (Elliot, 2014) and SNOMED (Systematized Nomenclature of Medicine) Clinical Terms (CT)[1] use in palliative care (Lau, 2010).

1 In 2014, the International Health Terminology Standards Development Organisation (IHTSDO) responsible for SNOMED CT officially changed the name so SNOMED CT no longer refers to Systematized Nomenclature of Medicine Clinical Terms, but rather just SNOMED Clinical Terms. It has become a trade name rather than an acronym.

Most of these evaluation studies focused on satisfaction, care quality, productivity and access dimensions of the BE Framework, with the addition of measures specific to eHealth systems as needed. Examples include turnaround time for imaging test results, patient travel time and cost, and SNOMED CT term coverage in palliative care. Most studies used mixed methods to collect and analyse data from multiple sources. Reported methods include survey, interview, literature review, service data analysis and modelling of benefit estimates. Reported data sources include provider and patient surveys, interview and focus group data, service utilization data, prior evaluation reports and published peer-reviewed evaluation studies and systematic reviews. Note that many of the evaluation studies were based on perceived benefits from providers and patients, or projected benefits based on model cost estimates.

The BE Framework has also been cited in a number of Canadian evaluation studies, commentaries and student reports. For instance, in their evaluation of a provincial drug information system, Mensink and Paterson (2010) adapted the use and satisfaction dimensions of the BE Framework to examine its adoption and evolution over time. Similarly Shachak et al. (2013) extended the HIT service quality dimension to include different end user support themes such as onsite technical and data quality support by knowledgeable staff. In their commentary on EHR success strategy, Nagle and Catford (2008) emphasized the need to incorporate benefits evaluation as a key component toward EHR success. O'Grady and colleagues (2009) discussed collaborative interactive adaptive technologies (e.g., social media). Six graduate-level theses that drew on the BE Framework have also been published. These include the evaluation studies on: a scanning digital prescriber order system by Alsharif (2012); end user support for EMR by Dow (2012); electronic occurrence reporting on patient safety by Elliot (2010); EMR implementation in an ambulatory clinic (Forland, 2008); a multidisciplinary cancer conferencing system detailed by Ghaznavi (2012); and characteristics of health information exchanges in literature (Ng, 2012).

Table 2.5

Examples of Canadian Evaluation Studies where the BE Framework was Applied

Authors	Setting	eHealth system	Evaluation Focus	Design/ Methods	Indicator/ Measures	Results
B.C. MOH (2011a)	Six health regions in British Columbia	Telehealth system for specialized oncology consults, provider education	Access to oncology service and provider education, travel time and cost	Patient and physician surveys, analysis of utilization	Consult/education service counts, travel time, patient and physician satisfaction	Interim results showed increased access, reduced travel time, high satisfaction level for patients and providers
B.C. MOH (2011b)	Two health regions in British Columbia	Telehealth system for ophthamology retinal screening	Telehealth quality, use, satisfaction, access, productivity, empowerment	Survey, pre/post service use	System function, info quality, usability, travel time, patient volume, satisfaction, change in # diabetic and retinal screening	100% satisfied with telehealth quality and use, some travel cost saving, fee code and improved scheduling to maximize service
B.C. MOH (2013)	Four health regions in British Columbia	Panorama vaccine inventory module	Productivity, module usability, adoption, support mechanisms	Survey and interview	Staff time efficiency, vaccine wastage cost and volume	Some benefits, below expectations, need to streamline steps, expand functions/use
Cousins and Baldwin (2014)	Ambulatory clinics in provincial region in British Columbia	eChart/EMR	Key performance indicators for eChart	Survey, chart review, focus group, document review	eChart quality, usage, satisfaction, patient flow, medication alerts, patient/ family experience	Overall satisfied – 42%, quality acceptable –system 50%, info 63%, productivity +/- 10%
Deloitte (2010)	Pan-Canadian	Generation 2 drug info systems	Expected benefits in quality and productivity, focus on safety	Prior evaluations, survey, interviews, utilization analysis, benefits modelling	Adverse drug events and admissions, med abuse, compliance, productivity	Estimated benefits $436m: quality $252m, productivity $184m

Table 2.5

Examples of Canadian Evaluation Studies where the BE Framework was Applied

Authors	Setting	eHealth system	Evaluation Focus	Design/ Methods	Indicator/ Measures	Results
Elliot et al. (2014)	One health region in Newfound-land and Labrador	Electronic occurrence reporting system (aka clinical safety reporting system)	Benefits and lessons	Mixed methods, pre/post design, surveys, interviews, focus groups, cases reported, project documents	Pre/post adoption cases reported, time to reporting, usability and satisfaction	Increased reporting, improved notification, satisfaction, issues in implementation
Ernst & Young (2014)	Pan-Canadian, based on 4 programs	Remote patient monitoring (RPM) systems	Expected benefits in care quality, access and productivity	Utilization data, literature review, interviews, surveys	Utilization, break-even, cost, caregiver burden, satisfaction, compliance	Moderate evidence on benefits especially larger scale programs, solutions emerging
Gartner, Inc. (2013)	British Columbia, province-wide	Diagnostic imaging, Drug info systems, telehealth systems	Estimated benefits in care quality, access and productivity	Estimates from pan-Canadian studies, B.C. data and interviews	Expected cost saving, productivity, patient transfer, satisfaction, adverse events, callbacks, medication abuse, compliance, travel time, access	Expected improvement in care quality, access and productivity in DI at $90m, DIS at $200m and telehealth at $15m
Hagens et al. (2009a, 2009b)	Pan-Canadian based on 4 provinces	Diagnostic imaging systems	Estimated benefits in quality, access and productivity	Mixed methods, pre/post adoption survey, utilization	Turnaround time, transfers, duplicate exams, productivity, communicat ion, cost per case	Estimated benefits in improved access 30-40%, efficiency $160-190m, turnaround time 41%, productivity 25-30% at $122-148m
Lau et al. (2010)	Palliative care program in one region	Palliative care info system (PCIS)	SNOMED CT quality and use in palliative care	Mixed methods, interviews, case analysis and system usability	SNOMED CT quality, use/satisfac-tion, care quality, productivity	Higher consistency with SNOMED encoded consult letter with better quality

Table 2.5
Examples of Canadian Evaluation Studies where the BE Framework was Applied

Authors	Setting	eHealth system	Evaluation Focus	Design/ Methods	Indicator/ Measures	Results
NLCHI (2010)	Province-wide, Newfound-land and Labrador	Telehealth systems for chronic disease manage-ment	Service access and patient empower-ment	Surveys, interviews, utilization, admin data analysis	Service utilization and access, travel time, cost, continuity, follow-up, satisfaction	Increased service and access, high satisfaction and improved service, capacity limit, privacy concerns
Praxia and Gartner, Inc. (2010)	Pan-Canadian	Telehealth systems	Benefits in care quality, access and productivity, use and satisfaction	Utilization analysis, survey, literature review, interviews, prior evaluation	Utilization, travel time, cost avoidance, satisfaction	Utilization, estimated cost avoidance $55m and travel $70m 2010, socio-technical issues
PwC (2013)	Pan-Canadian	Community based EMR systems	Estimated benefits in care quality, access and productivity	Literature review, interviews, benefit estimate modeling	Expected benefits in efficiency, safety, outcomes, utilization, interaction	Expected efficiency gain $177m, less adverse events and duplicate tests $123m

2.4.3 Benefit Evaluation Framework Usage in Other Countries

The BE Framework has also been adapted or cited by health informaticians from other countries in their eHealth evaluation work. In New Zealand, for example, Warren, Pollock, Day, Gu, and White (2011) and Warren, Gu, Day, and Pollock (2012) have incorporated the BE Framework as part of their standardized criteria pool of evaluation measures to be used selectively when evaluating eHealth systems. The criteria pool covers work and communication patterns, organizational culture, safety and quality, clinical effectiveness, IT system integrity, usability, vendor factors, project management, participant experience, and leadership and governance. Warren and colleagues advocated the use of action research to conduct evaluation based on a select set of evaluation measures from the criteria pool. This approach has been applied successfully in the evaluation of electronic referral systems (Gu, Warren, Day, Pollock, & White, 2012; Warren et al., 2012).

In their literature review of routine health information systems (RHIS) in low- and middle-income countries, Hotchkiss, Dianna, and Foreit (2012) examined nine conceptual frameworks including the BE Framework for adaptation to evaluate the performance of RHIS and their impact on health system functioning. Ahmadi, Rad, Nilashi, Ibrahim, and Almaee (2013) applied a fuzzy model called

Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) to identify the 10 most important factors in hospital EMR adoption based on 23 factors derived from the BE Framework. In addition, the evaluation toolkit for health information exchange projects from the United States Agency for Healthcare Research and Quality references a number of the measures from the BE Indicators Technical Report (Infoway, 2006) as recommendations for U.S. health information exchange projects (Cusack, Hook, McGowan, Poon, & Atif, 2010). A summary on the use of the BE Framework by these authors is shown in Table 2.6. See also the separate additional references section for Table 2.6.

Table 2.6
eHealth Evaluation in Other Countries where the BE Framework was Mentioned

Authors	Setting	eHealth system	Evaluation Focus	Design/ Methods	Indicators/ Measures	Results
Ahmadi et al. (2013) Malaysia	Private hospital	EMR systems	Ranking of most important factors in BE Framework	Survey, modeling with fuzzy technique for order performance by similarity to ideal solution (TOPSIS)	Likert-scale surveys with 23 parameters in 6 dimensions	10 important factors were patient choice, use strategies, ease of use, use intent, safety, communication, template, downtime, cost savings/profits
Cusack et al. (2010) United States	Multiple provider groups and healthcare organizations	Health information exchange (HIE)	Evaluation toolkit used to create an evaluation plan for HIE projects	A step-by-step process to determine HIE project goals and feasible measures	Measures for the process of creating a HIE and types of data used; and clinical process and outcome measures for the value propostion of HIE	Example measures listed in Sections II and III that are drawn from the BE Technical Indicators Report (2006)
Gu et al. (2012) New Zealand	Two health regions	Electronic referral in colorectal domain	Comparing two knowledge engineering (KE) project approaches	Mixed methods comparison of two cases	Criteria pool based on BE Framework dimensions	BE Framework guided examination of development approach, KE products, uptake and acceptance

Table 2.6
eHealth Evaluation in Other Countries where the BE Framework was Mentioned

Authors	Setting	eHealth system	Evaluation Focus	Design/ Methods	Indicators/ Measures	Results
Hotchkiss et al. (2012) United States	Low/middle income countries	Routine health information systems (RHIS)	RHIS performance, evaluation issues, improving evidence base	Literature review on conceptual frameworks and RHIS studies on effectiveness	Conceptual frameworks linking RHIS investments with performance, as inputs, processes, outputs, outcomes	BE Framework was one of nine conceptual frameworks cited
Nguyen and Bakewell (2011) Australia	One service provider organization	HIS for aged care providers	Impact of HIS adoption for aged care providers	Case study approach with mixed methods	HIS quality, use, satisfaction, and net benefits	Cited BE Framework but used revised D&M IS success model
Warren et al. (2011) New Zealand	National health IT systems	National shared care planning for long term conditions	Creation of a health IT evaluation framework	Action research approach with mixed methods	Criteria pool of measures for selection in specific evaluation studies	BE Framework dimensions included as part of criteria pool
Warren et al. (2012) New Zealand	Four healthcare organizations	Electronic referral systems	Comparison of four system features, adoption and benefits	Mixed methods	16 domains selected from criteria pool of evaluation measures	BE Framework dimensions as part of criteria pool, reported as lessons learned

2.4.4 System and Use Assessment Survey Tool Usage

The System and Use Assessment (SUA) survey tool has been applied in different eHealth evaluation studies across Canada. Recent examples include the evaluation of teleophthalmology and vaccine inventory management systems (Ministry of Health [MOH], 2011, 2013) and eChart (Cousins & Baldwin, 2014) in British Columbia, shared EHR in a western jurisdiction (Kuhn & Lau, 2014), and the drug information system in Prince Edward Island (Prince Edward Island [P.E.I.], 2010). A summary of these evaluation studies and how the survey tool was applied is shown in Table 2.7. See also the separate additional references section for Table 2.7.

There are also evaluation studies where the SUA survey has been adapted or cited. For instance, one Canadian jurisdiction – Nova Scotia – adapted the SUA survey tool to include more specific questions in the evaluation of their interoperable EHR picture archival and communication (PAC) and diagnostic imaging (DI) systems (for details, see Newfoundland and Labrador Centre for Health Information [NLCHI], 2014). Many of these studies are also available on the

Canada Health Infoway website. Other Canadian researchers adapted the survey tool to examine the quality and use of physician office EMRs (Paterson et al., 2010). In the United States, Steis et al. (2012) adapted the survey tool to examine user satisfaction with an electronic dementia assessment tool. In Saudi Arabia, Bah et al. (2011) adapted the tool to determine the level and extent of EHR adoption in government hospitals.

Table 2.7
Canadian Evaluation Studies where the S&U Assessment Survey Tool was Applied

Authors	Setting	eHealth system	Evaluation Focus	Design/ Methods	Indicators/ Measures	Results
B.C. MOH (2011)	Two health regions	Telehealth system for ophthalmology retinal screening	Telehealth quality, use, satisfaction, access, productivity, empowerment	Survey, pre/post service use	System function, info quality, usability, travel time, patient volume, satisfaction, change in # diabetic and retinal screening	100% satisfied with telehealth quality and use, some travel cost saving, fee code and improved scheduling to maximize service
B.C. MOH (2013)	Four health regions	Panorama vaccine inventory module	Productivity, module usability, adoption, support mechanisms	Survey and interview	Staff time efficiency, vaccine wastage cost and volume	Some benefits, below expectations, need to streamline steps, expand functions/use
Cousins and Baldwin (2014)	Ambulatory clinics in provincial health authority	eChart/EMR	Key performance indicators for eChart	Survey, chart review, focus group, document review	eChart quality, usage, satisfaction, patient flow, medication alerts, patient/family experience	Overall satisfied – 42%, quality acceptable - system 50%, info 63%, productivity +/- 10%
Kuhn and Lau (2014)	A western jurisdiction	Web-based shared EHR system	Use, satisfaction and impact of EHR	Survey and system use log	Adoption level, user satisfaction, impact	Info sharing improved, usage increased, issues with access, workflow integration

Table 2.7
Canadian Evaluation Studies where the S&U Assessment Survey Tool was Applied

Authors	Setting	eHealth system	Evaluation Focus	Design/ Methods	Indicators/ Measures	Results
Eapen and Chapman (2015)	Southwest Ontario	Mobile interface to EHR viewer	usability, impact on quality of patient care and productivity of health care providers	Survey	Adoption, usability, perceived productivity and quality	Users perceived the mobile interface of Clinical-Connect as useful but were neutral about the ease of use
P.E.I. (2010)	Province-wide	Drug information system	Stakeholder benefits, patient outcomes	Survey, admin data review	System/info quality, satisfaction, use, efficiency, drug compliance/ use	Slow but increasing use and satisfaction, need more training/ support

2.5 Implications

The BE Framework has proved to be a helpful conceptual scheme in describing and understanding eHealth evaluation. The BE Indicators Report and the SUA survey tool have become useful resources for healthcare organizations to plan and conduct evaluation studies on specific eHealth systems. The published evaluation studies that incorporated the BE Framework have provided a growing empirical evidence base where such studies can be reported, compared and aggregated over time. That said, there are both conceptual and practical implications with the BE Framework that should be considered. These implications are described below.

2.5.1 Conceptual Implications

There are conceptual implications related to the BE Framework in terms of its scope, definition and perspective. For scope, the BE Framework has purposely excluded organizational and contextual factors to be manageable. Note that the IS success model by DeLone and McLean (1992, 2003) has also made no mention of organizational and contextual factors. There was an assumption in that work that the IS involved were mature and operational systems with a stable user base, which made adoption issues less central. Yet many healthcare organizations are continuing to adopt and/or adapt eHealth systems due to changing legislation, strategies and technologies. As such, organizational and contextual factors can have a great deal of influence on the success of these eHealth systems. This limitation is evident from the contingent factors identified in the CIS

review by van der Meijden et al. (2003) and in the published evaluation studies from Canada and elsewhere.

This gap was one of the drivers for the development of the complementary National Change Management (CM) Framework (Infoway, 2012). Infoway facilitated the development of this framework though the pan-Canadian Change Management Network, with the intent of providing projects with practical tools to successfully implement eHealth change. Measurement is at the centre of the framework, surrounded by governance and leadership, stakeholder engagement, communications, training and workflow analysis and integration. Infoway has encouraged the use of the BE and CM frameworks in concert.

For definition, while the BE Framework dimensions, categories and measures have been established from empirical evidence over time, they are still concepts that can be interpreted differently based on one's experience and understanding of the meaning of these terms. In addition, the evaluation measures in the BE Framework are not exhaustive in what can be measured when evaluating the adoption and impact of myriad eHealth systems in different healthcare settings. As such, the caveat is that the definition of concepts and measures can affect one's ability to capture key aspects of specific eHealth systems for reporting, comparison and aggregation as part of the growing eHealth evidence base.

For perspective, it should be made clear that benefits evaluation and eHealth success are concepts that are dependent on the views and intentions of the stakeholders involved. There are many questions concerning what is considered "success" including: Who defines success? Who benefits from success? What is the trade-off to achieve success? These are questions that need to be addressed early when planning the eHealth system and throughout its design, implementation and evaluation stages. In short, the BE Framework can be perceived differently according to the various perspectives of stakeholders.

2.5.2 Practical Implications

There are also practical implications with the BE Framework in terms of how it is applied in real-life settings. One question raised frequently is how one should apply the framework when planning an evaluation study in an organization. To do so, one needs to consider the intent of the evaluation with respect to its focus, feasibility and utility.

For focus, one should identify the most important questions to be addressed and prioritize them accordingly in the evaluation. The BE Framework has a rich set of measures covering different aspects of eHealth adoption and impact, but one should not attempt to include all of them within a single study. For instance, if the focus of a study is to demonstrate the ability of an eHealth system to reduce medication errors, then one should select only a few key patient safety measures such as the incidents of adverse drug events reported over two or more time periods for comparison.

For feasibility, one should determine the availability of the data for the measures needed in the evaluation, as well as the time, resources and expertise avail-

able to design the study, collect and analyze the data, and report on the findings. For example, randomized controlled trials are often considered the gold standard in evaluating healthcare interventions. Yet it may be infeasible for the organization that is implementing an eHealth system to conduct such a trial since it is still adjusting to the changes taking place with the system. Similarly, an organization may not have the baseline data needed or the expertise available to conduct evaluation studies. In these situations the organization has to decide how feasible it is to capture the data or acquire the expertise needed. Capacity to conduct evaluation is another feasibility consideration, as more complex evaluations may require specialized skill sets of evaluators, funding, leadership support or other inputs that are limiting factors for some organizations.

For utility, one needs to determine the extent to which the evaluation efforts and results can inform and influence change and be leveraged for added value. The planning and conduct of an evaluation study can be a major undertaking within an organization. Executive and staff commitment is necessary to ensure the results and issues arising from the study are addressed to reap the benefits to the system. To maximize the utility of an evaluation study and its findings, one should systematically document the effort and results in ways that allow its comparison with studies from other organizations, and aggregation as part of the evolving empirical evidence base.

2.6 Summary

This chapter described the BE Framework as a conceptual scheme for understanding eHealth results. The framework has six dimensions in system, information and service quality, use and satisfaction, and net benefits, but organizational and contextual factors are considered out-of-scope. Since its debut in 2006, the BE Framework has been applied, adapted and cited by different jurisdictions, organizations and groups in Canada and elsewhere as an overarching framework to plan, conduct and report eHealth evaluation studies. Additional studies continue to be published on a regular basis. Recognizing its limitations in addressing contexts, there is a growing evidence base in the use of the BE Framework to evaluate the success of eHealth systems across different healthcare settings.

References

Alsharif, S. (2012). *Evaluation of medication turnaround time following implementation of scanning digital prescriber order technology*. MSc Internship Report in Health Informatics, Dalhousie University, Halifax, NS.

Bah, S., Alharthi, H., Mahalli, A. A. E., Jabali, A., Al-Qahtani M., & Al-Kahtani, N. (2011). Annual survey on the level and extent of usage of electronic health records in government-related hospitals in eastern province, Saudi Arabia. *Perspectives in Health Information Management, 8*(Fall), 1b.

DeLone, W. H., & McLean, E. R. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research*, *3*(1), 60–95.

DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems*, *19*(4), 9–30.

Dow, R. (2012). *The impact of end-user support on electronic medical record success in Ontario primary care: A critical case study*. MSc thesis in Information, University of Toronto.

Elliott, P. G. (2010). *Evaluation of the implementation of an electronic occurrence reporting system at Eastern Health, Newfoundland and Labrador (Phase One)*. PhD dissertation in Medicine, Memorial University of Newfoundland, St. John's.

Forland, L. (2007). *Evaluating the implementation of an electronic medical record for a health organization-affiliated family practice clinic*. MSc thesis in Health Informatics. University of Victoria, Victoria, BC, Canada.

Ghaznavi, F. (2012). *Design and evaluation of a multidisciplinary cancer conferencing platform*. MSc thesis in Biomedical Engineering. Chalmers University of Technology and University of Toronto.

Hagens, S., Zelmer, J., Frazer, C., Gheorghiu, B., & Leaver, C. (2015, February). Valuing national effects of digital health investments: An applied method. Paper presented at *Driving quality in informatics: Fulfilling the promise*, an international conference addressing information technology and communication in health, Victoria, BC, Canada.

Infoway. (2005). *Canada Health Infoway Inc. corporate business plan 2005–06*. Toronto: Author.

Infoway. (2006). *Benefits evaluation survey process — System & use assessment survey*. Canada Health Infoway benefits evaluation indicators technical report. Version 1.0, September 2006. Toronto: Author. Retrieved from https://www.infoway-inforoute.ca/en/component/edocman/resources/toolkits/change-management/national-framework/monitoring-and-evaluation/resources-and-tools/991-benefits-evaluation-survey-process-system-use-assessment-survey

Infoway. (2012). *Benefits evaluation survey process — System & use assessment survey*. Canada Health Infoway benefits evaluation indicators technical report. Version 2.0, April 2012. Toronto: Author.

Kuhn, K., & Lau, F. (2014). Evaluation of a shared electronic health record. *Healthcare Quarterly*, *17*(1), 30–35.

Lau, F. (2006). Increasing the rigor of health information system studies through systematic reviews? In R. Abidi, P. Bath, & V. Keselj (Eds.), *Proceedings of 11th International Symposium on Health Information Management Research (ISHIMR)*. July 14 to 16, Halifax, NS, Canada.

Lau, F., Hagens, S., & Muttitt, S. (2007). A proposed benefits evaluation framework for health information systems in Canada. *Healthcare Quarterly, 10*(1), 112–118.

Lau, F., Kuziemsky, C., Price, M., & Gardner, J. (2010). A review on systematic reviews of health information system studies. *Journal of American Medical Informatics Association*, *17*(6), 637–645. doi: 10.1136/jamia.2010.004838

Mensink, N., & Paterson, G. (2010). The evolution and uptake of a drug information system: The case of a small Canadian province. In C. Safran, H. Marin, & S. Reti (Eds.), *MEDINFO 2010* (pp. 352–355). Amsterdam: IOS Press. doi: 10.3233/978-1-60750-588-4-352.

Nagle, L. M., & Catford, P. (2008). Toward a model of successful electronic health record adoption. *Healthcare Quarterly*, *11*(3), 84–91.

Newfoundland and Labrador Centre for Health Information [NLCHI]. (2014). Nova Scotia post-implementation survey and interview results, March 2014. Retrieved from https://www.infoway-inforoute.ca/en/component/edocman/resources/reports/benefits-evaluation/2099-atlantic-canada-iehr-labs-benefits-evaluation-project-phase-2-nova-scotia

Ng, Y. (2012). *Key characteristics of health information exchange: A scoping review*. MSc report in Health Informatics. University of Victoria, Victoria, BC, Canada.

O'Grady, L., Witterman, H., Bender, J. L., Urowitz, S., Wiljer, D., & Jadad, A. R. (2009). Measuring the impact of a moving target: Towards a dynamic framework for evaluating collaborative adaptive interactive technologies. *Journal of Medical Internet Research, 11*(2), e20.

Paterson, G., Shaw, N., Grant, A., Leonard, K., Delisle, E., Mitchell, S., ... Kraetschmer, N. (2010). A conceptual framework for analyzing how Canadian physicians are using electronic medical records in clinical care. In C. Safran, S. Reti, & H. F. Marin (Eds.), *Proceedings of the 13th World Congress on Medical Informatics* (pp. 141–145). Amsterdam: IOS Press.

Shachak, A., Montgomery, C., Dow, R., Barnsley, J., Tu, K., Jadad, A. R., & Lemieux-Charles, L. (2013). End-user support for primary care electronic medical records: a qualitative case study of users' needs, expectations, and realities. *Health Systems, 2*(3), 198–212. doi: 10.1057/hs.2013.6

Steis, M. R., Prabhu, V. V., Kang, Y., Bowles, K. H., Fick, D., & Evans, L. (2012). Detection of delirium in community-dwelling persons with dementia. *Online Journal of Nursing Informatics, 16*(1). Retrieved from http://ojni.org/issues/?=1274

van der Meijden, M. J., Tange, H. J., Troost, J., & Hasman, A. (2003). Determinants of success of clinical information systems: A literature review. *Journal of the American Medical Informatics Association, 10*(3), 235–243.

References Cited in Tables

Table 2.3

Ammenwerth, E., & de Keizer, N. (2004). An inventory of evaluation studies of information technology in health care. Trends in evaluation research, 1982-2002. *International Journal of Medical Informatics, 44*(1), 44–56.

Balas, A. E., Boren, S. A., & Griffing, G. (1998). Computerized management of diabetes: a synthesis of controlled trials. *Journal of the American Medical Informatics Association, 5*(S), 295–299.

Balas, A. E., Austin, S. M., Mitchell, J. A., Ewigman, B. G., Bopp, K. D., & Brown, G. D. (1996). The clinical value of computerized information services. *Archives of Family Medicine, 5*(5), 271–278.

Cramer, K., Hartling, L., Wiebe, N., Russell, K., Crumley, E., Pusic, M., & Klassen, T. P. (2003). *Computer-based delivery of health evidence: A systematic review of randomized controlled trials and systematic reviews of the effectiveness of the process of care and patient outcomes.* Final report, part I. Edmonton, AB: Heritage Foundation for Medical Research.

Delpierre, C., Cuzin, L., Fillaux, J., Alvarez, M., Massip, P., & Lang T. (2004). A systematic review of computer-based patient record systems and quality of care: More randomized clinical trials or a broader approach? *International Journal for Quality in Health Care, 15*(5), 407–416.

Garg, A. X., Adhikari, N. K. J., McDonald, H., Rosas-Arellano, M. P., Devereaux, P. J., Beyene, J., Sam, J., & Haynes, R. B. (2005). Effects of computer-based clinical decision support systems on practitioner performance and patient outcomes: A systematic review. *Journal of the American Medical Association, 293*(10), 1223–1238.

Kaushal, R., Shojania, K. G., & Bates, D. W. (2003). Effects of computerized physician order entry and clinical decision support systems on medication safety. *Archives of Internal Medicine, 163*(12), 1409–1416.

Kawamoto, K., Houlihan, C. A., Balas, E. A., & Lobach, D. F. (2005). Improving clinical practice using clinical decision support systems: A systematic review of trials to identify features critical to success. *British Medical Journal, 330*(7494), 765–768.

Mitchell, E., & Sullivan, F. A. (2001). A descriptive feast but an evaluative famine: systematic review of published articles on primary care computing during 1980-97. *British Medical Journal, 322*(7281), 279–282.

Montgomery, A. A., & Fahey, T. (1998). A systematic review of the use of computers in the management of hypertension. *Journal of Epidemiology and Community Health, 52*(8), 520–525.

Sullivan, F., & Mitchell, E. (1995). Has general practitioner computing made a difference to patient care? *British Medical Journal, 311*(7009), 848–852.

van der Loo, R. P., Gennip, E. M. S. J., Bakker, A. R., Hasman, A., & Rutten, F. F. H. (1995). Evaluation of automated information systems in healthcare: An approach to classify evaluative studies. *Computer Methods and Programs in Biomedicine, 48*(1/2), 45–52.

van der Meijden, M. J., Tange, H. J., Troost, J., & Hasman, A. (2003). Determinants of success of clinical information systems: A literature review. *Journal of the American Medical Informatics Association*, *10*(3), 235–243.

Walton, R., Dovey, S., Harvey, E., & Freemantle, N. (1999). Computer support for determining drug dose: systematic review and meta analysis. *British Medical Journal, 318*(7189), 984–990.

Table 2.5

British Columbia Ministry of Health [MOH]. (2011a). *Evaluating the benefits: Telehealth — TeleOncology*. Initial benefits evaluation assessment. Victoria, BC: Ministry of Health.

British Columbia Ministry of Health [MOH]. (2011b). *Evaluating the benefits: Telehealth — teleOphthalmology*. Inter Tribal Health Authority and the Ministry of Health Services. Victoria, BC: Ministry of Health.

British Columbia Ministry of Health [MOH]. (2013). *Panorama vaccine inventory module*. Benefits evaluation report. Victoria, BC: Ministry of Health.

Cousins, A., & Baldwin, A. (2014). *eChart ambulatory project: EMR benefits measurement in a tertiary care facility*. eHealth Conference, Vancouver, BC, June 3, 2014.

Deloitte. (2010). *National impacts of generation 2 drug information systems*. Technical Report, September 2010. Toronto: Canada Health Infoway. Retrieved from https://www.infoway-inforoute.ca/en/component/edocman/resources/reports/331-national-impact-of-generation-2-drug-information-systems-technical-report-full

Elliott, P., Martin, D., & Neville, D. (2014). Electronic clinical safety reporting system: A benefits evaluation. *Journal of Medical Internet Research*, *2*(1), e12.

Ernst & Young. (2014). *Connecting patients with providers: A pan-Canadian study on remote patient monitoring*. Toronto: Canada Health Infoway. Retrieved from https://www.infoway-inforoute.ca/en/component/edocman/resources/reports/benefits-evaluation/1890-connecting-patients-with-providers-a-pan-canadian-study-on-remote-patient-monitoring-executive-summary

Gartner, Inc. (2013). *British Columbia eHealth benefits estimates*. Stamford, CT: Author.

Hagens, S., Kwan, D., Savage, C., & Nenadovic, M. (2009a). The impact of diagnostic imaging investments on the Canadian healthcare system. *Electronic Healthcare, 7*(4), Online Exclusive.

Hagens, S., Kraetschmer, N., & Savage, C. (2009b). Findings from evaluations of the benefits of diagnostic imaging systems. In J. G. McDaniel (Ed.), *Advances in information technology and communication in health* (pp. 136–141). Amsterdam: IOS Press.

Lau, F., Lee, D., Quan, H., & Richards, C. (2010). An exploratory study to examine the use of SNOMED CT in a palliative care setting. *Electronic Healthcare, 9*(3), e12–e24.

Newfoundland and Labrador Centre for Health Information [NLCHI]. (2010). *Evaluating the benefits — Newfoundland and Labrador provincial telehealth program: Chronic disease management*. St. John's: Author.

Praxia Information Intelligence, & Gartner, Inc. (2010). *Telehealth benefits and adoption: Connecting people and providers across Canada*. Toronto and Stamford, CT: Authors.

PricewaterhouseCoopers [PWC]. (2013). *The emerging benefits of electronic medical record use in community-based care*. Toronto: Canada Health Infoway.

Table 2.6

Ahmadi, H., Rad, M. S., Nilashi, M., Ibrahim, O., & Almaee, A. (2013). Ranking the micro level critical factors of electronic medical records adoption using toopsis method. *Health Informatics — An International Journal (HIIJ), 2*(4), 19–32.

Cusack, C. M., Hook, J. M., McGowan, J., Poon, E., & Atif, Z. (2010). *Evaluation toolkit. Health information exchange projects, 2009 update* (AHRQ Publication No. 10-0056-EF). Rockville, MD: US Department of Health and Human Services.

Gu, Y., Warren, J., Day, K., Pollock, M., & White, S. (2012). Achieving acceptable structured eReferral forms. In K. Butler-Henderson & K. Gray (Eds.), *Proceedings of the 5th Australasian workshop on Health Informatics and Knowledge Management (HIKM, 2012), Melbourne* (pp. 31–40). Darlinghurst, Australia: Australian Computer Society.

Hotchkiss, D., Dianna, M., & Foreit, K. (2012). *How can routine health information systems improve health systems functioning in low-resource settings?* Chapel Hill, NC: MEASURE Evaluation.

Nguyen, L., & Bakewell, L. (2011). Impact of nursing information systems on residential care provision in an aged care provider. In *ACIS 2011: Proceedings of the 22nd Australasian Conference on Information Systems : Identifying the information systems discipline* (pp. 1–10). Sydney: AIS eLibrary.

Warren, J., Pollock, M., Day, K., Gu, Y., & White, S. (2011). *A framework for health IT evaluation*. Wellington, New Zealand: Ministry of Health.

Warren, J., Gu, Y., Day, K., & Pollock, M. (2012). Approach to health innovation projects: Learnings from eReferrals. *Health Care and Informatics Review Online, 16*(2), 17–23.

Table 2.7

British Columbia Ministry of Health [MOH]. (2011). *Evaluating the benefits: Telehealth — teleOphthalmology*. Inter Tribal Health Authority and the Ministry of Health Services. Victoria, BC: Ministry of Health.

British Columbia Ministry of Health [MOH]. (2013). *Panorama vaccine inventory module* (Benefits Evaluation Report). Victoria, BC: Ministry of Health.

Cousins, A., & Baldwin, A. (2014). *eChart ambulatory project: EMR benefits measurement in a tertiary care facility*. eHealth Conference, Vancouver, BC, June 3, 2014.

Eapen, B. R., & Chapman, B. (2015). Mobile access to ClinicalConnect: A user feedback survey on usability, productivity, and quality. *Journal of Medical Internet Research, 3*(2), e35. doi: 10.2196/mhealth.4011

Kuhn, K., & Lau, F. (2014). Evaluation of a shared electronic health record. *Healthcare Quarterly, 17*(1), 30–35.

Prince Edward Island [P.E.I.]. (2010). *Prince Edward Island drug information system — Evaluation report*. Charlottetown: Government of Prince Edward Island.