**A framework for measuring the economic benefits of health information technology in primary care**

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**Abstract**

*Investment in health information technologies (HIT) rests on the idea that taxpayers will receive value for money. Demonstrating the benefits of such investment has proved elusive. To this point, the value proposition has tended to focus on the benefits experienced by individual practitioners, usually primary care clinics. This paper draws on the program evaluation concept of a logic model and the constituent results chains to create an evaluation framework for measuring the benefits arising from HIT adoption in primary care.*

**Introduction**

There are currently two approaches to economic benefit measurement of HIT. Some are particularistic and examine specific benefits in only selected domains. For example, a commonly alleged benefit is that HIT will increase time savings for all parties, which, when expressed as a monetary value, serves to create a financial payoff to the investment. Buntin, Burke, Hoaglin, and Blumenthal (2011) and Belletti, Zacker, and Mullins (2010) represent many studies that identify benefits based on provider surveys. DesRoches et al. (2008) present the attributes of an outpatient HIT system using four specific domains — health information and data, order-entry management, results management, and clinical decision support — and a series of sub-domains, each of which directly links to health outcomes. At a more general systems level, Lau (2011) concludes that the large investments made in HIT have shown “mixed results” in terms of benefits. He further argues for an evaluation framework that operates at the micro, meso, and macro level. The micro level represents benefits as emanating from health care quality, productivity, and access; the meso level focuses on implementation of HIT; and the macro level stresses the role of standards, governance, and socio-economic/political trends in shaping benefits.

These approaches all serve useful purposes in describing how HIT can support increased health outcomes. However, they are not sufficiently general nor concrete to support actual measurement of outcomes in a form that will allow estimation of the value for money obtained from the investment in HIT. This paper attempts to show that a general HIT benefit evaluation framework that emerges from two theoretical sources may be created.

1. The literature on HIT maturity models has refined the concept to comprise a set of system attributes that support behaviour change and resulting changes in health status.
2. The concept of a logic model drawn from the program evaluation literature provides the general framework for examining the health status changes for component attributes and drawing these into a general evaluation framework. This framework supports a benefit measurement strategy.

This paper proceeds in three parts. The first considers how HIT in a primary care setting may be characterized as a series of attributes supporting informational needs of practitioners and patients. Increased timeliness and breadth/depth of information content within the HIT should lead to behaviour changes that have measureable changes in health outcomes. The second part of the paper places the attributes into a general benefit evaluation framework that supports the identification of a series of results chains. Each of these results chains forms a causal logic capable of empirical assessment, which, in turn, supports the measurement of benefits. Aggregating the benefits across the entire logic model creates the general measure of HIT benefits. The third part of the paper considers the range of empirical assessment that supports measurement of HIT benefits arising from the attribute – behaviour change – status outcome causal logic. The paper focuses on primary care to ensure that the discussion remains tractable and grounded.

**HIT attributes, behaviour change, and health outcomes**

It is easiest to start the discussion using, as an example, a single health care clinic, which can range from a single physician and assistant (increasingly rare) to group practices with diverse physician teams and other health care professionals, plus support staff.

HIT presents practitioners and patients with new information. It is this new information that prompts the behaviour changes that lead to improved health outcomes. Table 1 presents a characterization of HIT (framed in terms of electronic medical records)[[10]](#footnote-10) that typifies a primary care setting. The important step in the development of a general evaluation strategy is to associate the consequential information content that occurs for each attribute. Associated with the increased information content is a behaviour change. Under the assumption that the practitioner and patient will act on the opportunities presented by the new information, improved health outcomes will emerge.

| **Table 1: High-level EMR attributes and implied informational consequences** |
| --- |
|  | **Attribute** | **Information consequence** |
|  | Health information (patient demographics, medical/surgical history, allergies) | * Increased information on patient attributes (family history, current health status, lifestyle choices…)
* Reduced recall errors (increased accuracy of patient attributes)
* Reduced variability and comprehensiveness of patient data
* Increased information on patient risk factors (behavioural, genetic…)
 |
|  | Lab management (ordering tests/diagnostic images, receiving results, reviewing results) | * Reduced time for information retrieval (results)
* Increased range of tests
* Test out of range values
 |
|  | Pharmaceutical management (prescribing, renewals, interaction assessment, cost control) | * Reduced time in renewal management
* Increased information for treatment selection
* Increase in signals for contraindication
* Increased cost data on alternatives
 |
|  | Decision support (screening, chronic care testing and monitoring, medical care management across classes of patients [see also Practice management]) | * Increased information to identify risk factors in patients
* Increased monitoring of compliance (renewal monitoring)
* Algorithmic diagnoses (test results interpreted in the context of patient history)
 |
|  | Patient engagement (education, motivation, information sharing) | * Increased patient comprehension of condition and treatment strategy
 |
|  | Administration practice management (scheduling, billing, data management, evaluation of individual and team performance, use of collected data for research into practice) | * Increased information on scheduling options
* Increased information for invoicing, resource management, HR management
* Increased data on staff productivity
* Use of data to increase understanding of treatment effectiveness
* Data on adverse outcomes
 |
| Adapted from Price and Lau (2011) |

Consider Attribute 1 (Health Information) comprising tombstone data (age, gender, family history, surgical/condition histories, and other immutable patient characteristics such as genetic testing results information). The full implementation of this attribute requires patient recall, willingness to share history, and the recovery of information from prior interactions with the health care system. In some cases, patients will not be able to supply full information, such as in cases where adoptees have no knowledge of parental conditions. However, the informational consequence of this attribute being fully implemented is a range of additional data to which practitioner and patient may respond.

The issue of implementation is clearly important. The information content under this attribute depends on the inherent capacity to support data acquisition. It also depends on implementation of HIT by the practitioner and his/her skill in using the software. Our assumption for this paper is that each provider has implemented the HIT to the maximum level. Empirical measurement of HIT benefits will need to measure the implementation or “maturity” of the technology.

Table 2 extends the translation of attributes to information consequences to the *selected* behavioural changes. Other responses may occur depending on the setting and the features of the HIT.

Again, with respect to Attribute 1, the increased information on patients supports increased screening selection aligned to risk factors. For example, evidence might suggest that routine screening for some conditions poses risks to patients in general. Screening might be indicated for those with a family history. The recent debate over the prostate-specific antigen (PSA) is a case in point, where a false positive for the PSA may result in biopsies that induce serious complications. Other types of cancer screening, such as mammograms, also present potential adverse outcomes associated with false positives. Increased reliability and text of patient data within the HIT supports more informed decision-making. Benefit evaluation of HIT depends upon a complete enumeration of possible behaviour responses.

| **Table 2: High-level EMR attributes, implied informational consequences, and behavioural responses** |
| --- |
|  | **Attribute** | **Information consequence** | **Selected possible behavioural responses** |
|  | Health information (patient demographics, medical/surgical history, allergies) | * Increased information on patient attributes (family history, current health status, lifestyle choices…)
* Reduced recall errors
* Increased information on patient risk factors (behavioural, genetic…)
 | * Improved screening and diagnostic targeting
* Increase in substantive contact in collecting information on current condition leading to increased patient engagement
 |
|  | Lab management (ordering tests/diagnostic images, receiving results, reviewing results) | * Reduced time for information retrieval (results)
* Increased range of tests
* Reduce errors in ordering tests
 | * Earlier diagnosis and treatment initiation
* Improved diagnosis and treatment plans
 |
|  | Pharmaceutical management (prescribing, renewals, interaction assessment, cost control) | * Increased information on treatment options
* Contraindication flagged at time of prescription
* Increased cost data on alternatives
* Reduced time in renewal management
* Renewal data
 | * Improved selection of medication
* Fewer errors; reduced incidence of interactions/contraindications
* Faster fulfillment → earlier treatment and reduced time in renewal management
* Selection of lower cost equivalents
* Verification that patients are following protocols and increased adherence to treatment
 |
|  | Decision support (screening, chronic care testing and monitoring, medical care management across classes of patients [see also Practice management]) | * Increased information to identify risk factors in patients
* Increased monitoring of compliance (renewal monitoring)
* Algorithmic diagnoses (test results interpreted in the context of patient history)
* Increased status monitoring
 | * Increased screening rates
* Better treatment plans → faster recovery
* Increased screening rates and increased numbers involved in screening
* Increased monitoring of compliance (renewal monitoring)
 |
|  | Patient engagement(education, motivation, information sharing) | * Increased patient comprehension of condition and treatment strategy
 | * Patients adopt healthier lifestyles
* Increased patient comprehension of condition and participation in treatment strategies
* Increased motivation and adherence to treatment regimes
 |
|  | Administration and practice management(scheduling, billing, data management, evaluation of individual and team performance, use of collected data for research into practice**)** | * Increased information on scheduling options
* Increased information for invoicing, resource management, HR management
* Increased data on staff productivity
* Data on outcomes
 | * Higher throughput of patients
* Increased effectiveness in management of practice human resources
* Increased understanding of treatment effectiveness
 |
| Adapted from Price and Lau (2011) |

The next step in the result chain is to link each attribute to immediate outcomes. Table 3 presents this step, omitting the intermediate informational consequence and behaviour change. These immediate outcomes form the empirical base for measuring the immediate benefits of HIT. As will be made clear in the next section, in the first instance, benefit evaluation of HIT should focus on immediate or short-term outcomes.

| **Table 3: High-level EMR attributes and immediate outcomes (benefits)** |
| --- |
|  | **Attribute** | **Possible behavioural responses** | **Selected potential immediate outcomes (benefits)** |
|  | **Health information**  | * Improved screening and diagnostic targeting align to patient attributes
* Improved treatment modalities
 | * Faster recovery with lower morbidity/mortality and fewer adverse outcomes
 |
|  | **Lab management** | * Faster diagnostics
* Earlier initiation of treatment
 | * Faster recovery with lower morbidity/mortality and fewer adverse outcomes
 |
|  | **Pharmaceutical management**  | * Fewer errors (handwriting)
* Faster fulfillment → earlier treatment
* Avoidance of interactions
* Selection of lower cost equivalents
* Verification that patients are following protocols
 | * Improved outcomes (patients follow protocols)
* Reduced adverse events
* Lowered treatment costs
 |
|  | **Decision support**  | * Increased screening rates
* Increased immunization
* Better treatment plans → faster recovery
 | * Earlier diagnosis of disease
* Reduced incidence of disease
* Faster recovery
* Reduced time loss from employment and education
 |
|  | **Patient engagement**  | * Patients adopt healthier lifestyles
 | * Reduced incidence of disease
* Delayed onset of disease progression (chronic conditions)
* Increased immunization leading to lower incidence/consequences
 |
|  | **Administration and practice management**  | * Higher throughput of patients
* Increased practice profitability
* Changed/better chronic disease management
 | * More patients screened, diagnosed, treated
* Increased compensation for staff
* Delayed onset of disease progression
 |
| Adapted from Price and Lau (2011) |

The definition of immediate benefits poses measurement challenges. For example, one possible outcome of HIT is more effective patient engagement, leading to increased screening and immunization rates. This will then lead to additional downstream benefits in the form of earlier diagnosis/treatment, reduced disease incidence (e.g., flu), earlier treatment of serious illnesses, and delayed co-morbidities for chronic diseases. The critical point is that the increased screening and immunization rates need to be linked directly to the HIT. Since many influences exist to raise screening rates (media campaigns, the health literature, and peer influence), measuring the independent effect of HIT on screening and immunization rates from these other influences becomes the central evaluation issue

# Toward a causal logic model of EMR benefit

The basic evaluation building block is the results chain that shows the translation of inputs (HIT) into outputs (increased information) to immediate and intermediate outcomes. In principle, each attribute supports a results chain, as shown in Figure 1. The four essential conditions for an evaluation logic model are: inputs → activities → outputs → outcomes (Frechtling, 2007). For expository simplicity, we have collapsed inputs and activities into a single step.



**Figure 1: Results chain for Attribute 1**

Collecting each of the results chains supports a general benefit evaluation framework for HIT, as appears in Figure 2. The arrows at the left are associated with six selected attributes. Many possible behavioural changes emerge from each attribute, but for the moment, focus on only one. Likewise, assume that only a single immediate outcome results from the behaviour change. Benefit evaluation of HIT requires two steps:

1. The behavioural changes must be shown to flow from the attribute and not other internal or external factors.
2. In a similar vein, the immediate outcomes must be a unique result of the attribute-induced behavioural change.

A feature of immediate outcomes is that their existence depends largely on the nature of the intervention. If one needs to qualify whether an outcome logically and uniquely depends on the outputs (here the behaviour change), then the connection between output and outcomes needs to be drawn tighter.

The importance of measuring the immediate outcomes for each attribute and creating a counterfactual framework that tests whether outcomes can be linked to the outputs produced by HIT cannot be overstated. Section 3 addresses this in more detail.

Figure 2 shows just one selected behavioural change for each attribute. Typically, attributes and the attendant hardware/software features, as well as practice modalities on how the HIT is actually implemented, could result in each attribute producing a range of behaviour changes on the part of providers and patients.

Using Attribute 1 again, the results chain shown in Figure 1 becomes the upper arm of the full benefit evaluation logic model. For the most part, by restricting the results chain to a single behavioural response, a single immediate outcome may be identified. It is possible to imagine that a behavioural response could produce more than one immediate outcome, as shown in Attribute 3 – Pharmaceutical Management, where two immediate outcomes result. In principle, all the attributes will support a range of behavioural responses and consequential immediate outcomes. We have elected to maintain the simplicity of presentation by focusing on the salient issues.



**Figure 2: HIT Benefits Logic Model**

The longer term benefits that are typically attributed to HIT emerge as a result of one or more immediate outcomes. The story becomes more complex, however, for three reasons. First, longer term benefits may flow from more than one immediate outcome, as shown for the incidence of disease. Second, multiple long-term benefits may emerge from the immediate outcomes. Third, and most problematic, is that external to the logic model are external or “confounding” factors. For example, HIT may increase the rate at which providers encourage patients to complete flu immunizations, especially for populations at risk. At the same time, public health agencies may conduct publicity campaigns to encourage immunizations. Separating the attribution of the outcome of increased immunization rates from the context of increased public health promotion becomes the task of the evaluation methodology, to which we now turn.

**Evaluation methods for measuring HIT benefit**

Ideally, evaluations should create a counterfactual developed through random assignment. Comparing immediate outcomes, such as screening rates for cancer, medication errors, or completion of standards of care for diabetes, for providers with and without HIT reveals the benefit of HIT. Benefits will be measured easily under the assumption that the indicators are positive for the HIT practices (e.g., increased screening rates) *and* that HIT was assigned to a randomly selected subset of providers. Of course, HIT is never implemented by a random subset, and alternate quasi-experimental methods are needed to infer benefit.

Quasi-experiments refer to a range of methodologies designed to replicate the inferential power of a randomized experiment (DiNardo, 2008). Included designs are the following:

* Difference-in-differences
* General multivariate regression
* Pre-post time series
* Regression discontinuity
* Case-control designs
* Propensity score matching
* Instrumental variables
* Cohort models
* Panel analysis
* Natural experiments
* Simulation and projection models

The focus on benefit measurement for HIT must be to verify that the new technology and practices have initiated the required behavioural changes *and* that these have created immediate outcomes that are plausibly linked to longer-term changes in health outcomes. Confounding factors require very rich micro data to support the statistical analysis using quasi-experimental methods. Therefore, rather than a general estimate of the benefit of HIT, which would be very complex, a more fruitful approach is a series of smaller (local) studies that show progress of each *input → output → immediate outcome* results chains.

Any of the above quasi-experimental designs applied to HIT benefit measurement has three core information requirements. First, it must be possible to rank the implementation of HIT for any provider. This may be through self-report or some other audit process. Jurisdictions that have specified electronic medical record systems will usually require participating providers to maintain records on the level of implementation. Only with measurable variation in HIT implementation is it possible to develop the contrast needed to associate variation in outcome with variation in implementation.

Second, the HIT needs to be characterized using a common framework, such as the attributes in Table 1. This is certainly not the only characterization, but any model of HIT for primary care needs such a framework to support the various results chains that will be studied.

Third, measurement of the immediate outcomes requires reliable and valid data. In a worst-case scenario, this information may be derived from sample surveys of patients who request self-report information on participation in certain practices as well as attendance at primary care centres. Post- survey stratification will support classification of the information by level of HIT (obtained through independent means). It is more desirable to collect immediate outcome data from the large payer database maintained by government, insurers, and health management organizations. Thus, measurement of HIT benefits requires data development to create unified information on providers’ use and behaviours at the patient level (attendance at health screens, participation in immunizations, etc.). It is also important that the datasets include detailed information on patient characteristics such as education, age, and gender, since these are likely to influence response to the opportunities presented by HIT.

The benefit measurement strategy should focus on showing the connection between immediate outcomes and the HIT attributes. Inference to longer term outcomes will not usually be possible, but may be inferred on the basis of information in the literature. Several examples follow that show how one might assess HIT results chains using quasi-experimental methodology.

*Example 1: Cancer screening (Health information - Attribute 1)*

Cancer screening rests on the assumption that treating cancers early reduces mortality, extends life, and lowers costs of care. It is possible to forecast elements of these benefits using a variety of models. For example, it is possible to show lower treatment costs over the long term as a result of increased use of the fecal occult blood test (FOBT) and mammograms (Will, B.P. et. al. 2000). If health practitioners with HIT have a higher rate of screening for those at risk (lifestyle or family history) than those not using HIT, then the financial benefits of using electronic medical records can be quantified in terms of reduced treatment costs, extended work lives, etc. (Heitman, Hilsden, Au, Dowden, & Manns, 2010 and Greif, 2009). Manitoba Health (2011) presents a Markov model of the cost savings arising from three cancer screening programs (colorectal, breast, and cervix). Using this form of simulation analysis will support an estimate of the system cost savings from increased screening, and this forms part of the value for money benefit of HIT. Extending this to estimate the recovered time and quality of life will only increase the measure of benefit.

The important caveat is that the projected future benefits of screening need to be unambiguous. While screening for breast and colorectal cancers forms a standard element of evidence-based primary care, screening is also controversial. The recent reconsideration of PSA testing is a case in point. Other concerns have emerged that qualify the universal support for cancer screening (Berg 2010; Brawley et. al. 2011; Brodersen, Jorgensen, & Gotzsche, 2010; and Woolf & Harris, 2012). If screening poses harms, then HIT that increases participation in screening may reflect a negative return. At this time, the weight of evidence-based guidelines appears to support screening, and therefore, using projections of benefit based on increased activity would seem to remain a reasonable method for inferring benefit of HIT. The lesson is clear. The creation of a value statement about HIT depends on the validity of the immediate outcomes that derive from the behaviour change induced.

*Example 2: Influenza immunization (Patient engagement - Attribute 4)*

The economic benefits arising from flu vaccination are well-documented (Lee et al., 2010). Indeed, since the original Axnick study (Axnick 1969), immunization has been associated with positive economic benefits, typically arising from the recovered work time and associated lifetime wages as well as reduced care for those who may experience serious adverse effects of the disease.

The process of establishing value for money for immunization would be similar to the process used for cancer screening. The incremental value of HIT in this attribute would simply be the projected economic future returns from vaccination accruing to the increased numbers who participate in vaccinations due to the use of these technologies by practitioners. The critical requirement is to establish incremental participation in flu vaccination due to the use of HIT, since so much public health policy exists to raise participation rates. This illustrates the nature of the challenges to measuring the benefits of HIT.

*Example 3: Diabetes managed proactively (Decision support – Attribute 5)*

A commonly cited advantage of increased capacity in primary care is improved management of chronic conditions such as diabetes. This improved care may arise through better management of “pre-diabetic” conditions in an effort to forestall the onset of full diabetes and in the management of those with diagnosed diabetes to delay co-morbidities that shorten life and draw heavily on health system resources. O’Brien et al. (2003) and Stevens et al. (2004) are examples of this literature.

As with projections of lifetime costs of detecting cancers early, it is possible to associate increased management of diabetes with cost reductions. HIT-enabled primary care is presumed to improve the practitioner’s capacity to manage patients to specific standards. Maintaining blood pressure and blood lipid control are two central strategies to managing the emergence of co-morbidities associated with diabetes. Aside from prolonging quality of life (including attachment to the workforce), systems savings accrue from delaying the need for complex procedures such as dialysis. Manitoba Health (2011) presents a Markov model of the cost savings arising from improved management of diabetes.

**Summary**

This paper has argued that the estimation of the economic benefits of HIT requires the development of a logic model and framework aligned to the attributes of HIT as implemented. Using primary care practices as the foundation, we have shown that it is possible to create the basis for testable propositions about the incremental benefit of HIT. The critical requirement is that the attributes of any information technology enable behavioural changes that lead to immediate outcomes. Using local studies that draw on provider and patient attributes, it is possible to link inputs to outputs and then immediate outcomes that can serve as the basis of credible projections of economic benefit.

**Technical Appendix**

| Table A1: High-level EMR attributes and behaviour change (within single delivery clinic) |
| --- |
| **Attribute** | **Potential behavioural change** |
| 1. **Health information**
 |
| 1. Patient demographics
 | * Reduced time in re-recording information
* Creation of primary care plans according to guidelines
* Reduced clerical time by providers

…. |
| 1. Medical/surgical history
 | * Reduced time in identifying CIHI-recommended monitoring
* Recommended monitoring implemented

…. |
| 1. Allergies
 | * Potential pharmaceutical interaction noted (e.g., automatic warning when penicillin prescribed)

… |
| 1. Family history available
 | * Recommended screening flagged, ordered
* Team members can monitor and participate in care

…. |
| 1. **Lab management**
 |
| 1. Ordering tests/diagnostic images
 | * Timely results leading to faster and additional testing, then eventually to better diagnoses resulting in faster treatment
* Closer monitoring of medication side effects
* Reduced errors in ordering tests
* Faster confirmatory tests (control of false negatives and false positives)
* More testing throughput

…. |
| 1. Receiving results (electronic)
 | * Timely results leading to faster and additional testing, then eventually to better diagnoses resulting in faster treatment
* Closer monitoring of medication side effects
* Faster confirmatory tests (control of false negatives and false positives)
* More testing throughput
* Reduced clerical time

…. |
| 1. Reviewing results
 | * Timely results leading to faster and additional testing, then eventually to better diagnoses resulting in faster treatment
* Closer monitoring of medication side effects
* Faster confirmatory tests (control of false negatives and false positives)
* More testing throughput

…. |
| 1. **Pharmaceutical management**
 |
| 1. Prescribing
 | * Fewer errors (handwriting – reduced errors)
* Faster fulfillment
* Avoidance of interactions
* Minimization of overprescribing

….. |
| 1. Renewal management
 | * Monitoring of compliance
* Rapid follow-up when patients fail to comply

…. |
| 1. Interaction assessment
 | * Reduction of adverse interactions

…. |
| 1. Cost control
 | * Selection of lower cost equivalents

…. |
| 1. **Decision support**
 |
| 1. Screening
 | * Increased screening rates
* Increased numbers involved in screening

…. |
| 1. Chronic care testing and monitoring
 | * Increased chronic disease monitoring
* Faster adjustment of medications

…. |
| 1. Medical care management across classes of patients
 | * Better allocation of clinic resources in managing patients
* Amalgamation of services
* Alignment of specializations in support of patients
* Increased use of guidelines and evidence-based practice

…. |
| 1. **Patient engagement**
 |
| 1. Education
 | * Patients understand condition
* Patients become more proactive with respect to care

…. |
| 1. Motivation
 | * Patients are motivated to follow protocols (e.g., weight reduction, exercise)

…. |
| 1. Information sharing
 | * Motivate patients, who then influence family and friends

…. |
| 1. **Administration**
 |
| 1. Scheduling
 | * Providers can treat more patients
* Providers are more profitable

…. |
| 1. Billing
 | * Providers are more profitable

…. |
| 1. Records management
 | * Providers manage more patients
* Overall systems information increases

…. |
| 1. **Practice management**
 |
| 1. Evaluation of individual and team performance
 | * Providers are better able to manage human resources
* Providers identify professional development

…. |
| 1. Use of collected data for research into practice
 | * Providers gain insight into care management improvements

…. |

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10. The term “health information technology” encompasses many elements, such as electronic medical records, electronic health records, etc. The distinction among these definitions is not germane here. [↑](#footnote-ref-10)