

A framework for information systems evaluation: the case of an integrated community-based health services delivery system

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Abstract

Information Systems (IS) theory concentrates on getting the right information at the right time in the right format to the right user. The development of information systems, then, requires focus on organizational objectives, designs and dynamics as much as it requires focus on the procurement of the most appropriate hardware and software. The essence of "systems analysis" should not focus on computer-related concerns, but rather focus on the root of the problem which is the need for the right information. Moreover, not only should this analysis focus on the functionality of the organization but also on the improved effectiveness derived from the new or upgraded information system. In this paper, we present information – in the form of outcome measures – which are needed to initiate, and subsequently evaluate health delivery performance within Integrated Community-Based Health Delivery Systems.

Information systems in health care

Improving efficiency requires knowledge of current inefficiencies, and improving effectiveness requires an understanding of the measurable outcomes of health care. No process can be improved without knowledge of, or the existence of, performance measures. Information Systems (IS) provide the infrastructure by which performance measures can be generated. The acceptance of the role of information systems and technology as an integral component of a decentralized model, delivering a "seamless continuum of care", must be recognized. Often, the best way to accept changing technology is to see the benefits that new technology can bring (Tichy, 1982).

The majority of the IS emphasis in the health-care field to date has been on finding the optimal hardware and software configuration. However, what the industry needs, quite different from the current research orientation, is analysis focused on the use of these computerized information systems. For instance, the efforts to develop a community health information network (CHIN) harmonize well with other ongoing initiatives to create an information exchange network among government agencies, health-care centers, educational institutions and private sector partners. The best way to bring these initiatives forward is to provide the motivation for collaboration. The creation of measures for benchmarking which can be used for day-to-day management is just such a "catalyst for change" (Stearns and Mazie, 1996).

Strategic objectives of an information system

In short, the objectives can be enumerated simply: to improve the efficiency of information transfer within the health-care industry. Consequently, a mechanism for sharing information throughout the community is required (Neumann *et al.*, 1996). In addition, the development of standard forms for the transfer of

information among independent systems must be established.

It is becoming increasingly understood that a significant knowledge of state-of-art technology is needed in the development of effective IS. Recent literature has focused on the need to develop information systems for health networks but fall short in the prescription of how to do this development. For example, Pawola and Klineman (1996) suggest two key objectives:

- 1 to get "organization's information needs progress[ed] to a more advanced state";
- 2 to base IS on "what information systems can and cannot do." (Pawola and Klineman, 1996, p.49)

What is missing is the answer to the question: how can we achieve these two objectives? This is extremely difficult because the knowledge that is required to address this issue is resident with two very distinct groups. The CIO (IS group) is extremely knowledgeable about information systems capabilities. The CEO (management and executives) is very competent in describing high-level organizational information requirements. To be effective, these two groups must work together to share their knowledge in order to design and develop information systems strategy for the entire organization (Tan, 1995, p. 349).

Unfortunately, with very little successful experience, the vision and strategy that drive the objectives which normally force the development of IS structure in other industries does not exist in health care. Many health-care executives are not intimately familiar with technology – at least not enough to optimally design information systems. Hence, the IS development has been very slow (Gewertz and Goode, 1997).

Community Health Information Networks (CHINs)

CHINs can be defined as an infrastructure (part electronic and part database) that facilitates the "communication of patient information (clinical, demographic and cost) among health care providers" (Volkoff and Newson, 1997, section C5). CHINs are

characterized by the voluntary nature of the partnership – unlike Integrated Delivery Systems (IDS) – whereby the partners in the CHIN remain as separate corporate entities. CHINs, by definition, require that patient data must be accessible from any “point in the continuum of care” (Work and Pawola, 1996).

The move to implement CHINs has started in Canada, however, with varying degrees of only moderate success. The major challenge has been to bring disparate groups together. For example, in New Brunswick, the Government’s authority ensured a certain level of co-operation. Unfortunately, it wasn’t enough to guarantee success. In Toronto (Healthlink), fostering collaboration required a substantial ongoing investment. On Vancouver Island, the physicians first had to convince the teams within their clinics to support the idea of an electronic office. CHINs require a significant amount of time and investment. For this reason, the participants in a CHIN must be totally committed to enable it to function well and perform the much needed information integration (Volkoff and Newson, 1997).

Waterloo Health Partnership Project – a CHIN in development

The Region of Waterloo (Ontario) has been planning and developing a CHIN since the middle of 1994. The Mayor’s Office of the City of Waterloo, Waterloo Home Care Program, Waterloo VON and Red Cross, Community Care Access Centers, St Mary’s and Grand River Hospitals and physicians have all committed resources and have been developing the architecture for a four-phased automation project. In general, it is hoped that data and information transfer will occur in all directions between all of the members.

To date, the Waterloo project has completed the first phase for the local institutions and health-care service providers. The first phase of the system provides electronic connectivity with a move toward the development of a modem pool for dial-in access to independent providers, such as, family practitioners. The next phase would be the development of a Central Patient Index (CPI) which would provide demographic information on clients receiving services, and would ultimately provide encounter information. The development of standard forms for the transfer of information among independent systems would accompany this phase. As part of this philosophy, centralized assessment and intake could be enhanced over existing systems. The ultimate goal

(final phase) would be the development of a comprehensive Centralized Patient Record (CPR).

For the Waterloo CHIN, any delay (such as over five years to achieve phase one completion) in going ahead with information transfer in an online environment can be attributed to many factors:

- a lack of understanding of the true current (and near future) capabilities of IT;
- a deep-seated concern regarding system security and confidentiality;
- a need for control over data and information from each of the organizations in the network;
- a difficulty in seeing and quantifying the benefits of integrated information systems.

The most important issue on this list is the last. Quantifying costs is usually very straightforward. However, quantifying the benefits and matching the benefits to some distant time-line is extremely difficult even for the most experienced IT users (Laudon and Laudon, 1996). In order to overcome this problem, the approach applied was to define as many benefits as accurately as possible. Consequently, a group of health-care professionals was brought together to consider these constraining factors and to discuss possible solutions. Involved in this group decision-making process were representatives from the community and long-term care sectors, home care, nursing homes and centers for seniors and community care access centers. It was agreed that one very tangible benefit would be the creation of useful information (i.e., performance indicators) that would not otherwise be possible in the current health system IS environment.

This group, over the course of a number of in-person meetings, identified three measures of performance. These three components make up a Quality Index in an attempt to provide some insight into the magnitude of the impact from improved information throughout their own health-care system or CHIN. These measures can then be benchmarked to provide standards for the industry in an attempt to quantify the true effectiveness (in terms of both financial and clinical perspectives) derived from integrating IS initiatives. It is hoped that the outcome from the generation and management of these performance components will provide the incentive to continue the CHIN partnership. In addition, should the project evolve as expected, the appreciation of IT capabilities will drive the need for further connectivity and integration.

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Measures of quality

Regional CHINs need to be established in order to meet the often complex needs of patients in an efficient and timely way. The first step is to connect systems with partners and commit to the development of an integrated IS. This is an evolving organizational design with more questions than answers – but the solutions will come from the organizational preparedness to design, act and constantly create new shared applications which ultimately lead to comprehensive electronic information transfers. From a study performed in 1995, it was reported that some of the major problems in the health-care system were seen to be (Mercer *et al.*, 1996):

- unclear access points;
- inadequate information;
- inconsistency and inequity of services;
- fragmentation;
- multiple assessments;
- inadequate accountability;
- duplication;
- inadequate complaints and appeals mechanism;
- lack of holistic approach;
- lack of planning and strong linkages between institutional and community care;
- information technology underutilized;
- inadequate staff training.

In addition, priorities for service and the rationing of resources through waiting lists and reduced length of stays can only be established through improved system data. Current decision making by clinicians and managers is no longer acceptable. The compartmentalized decision making of the various sub-units in health care is the major contributing factor to the current disparate and inefficient array of services.

Information Technology (IT) benefits

The benefits from IT investment, for the most part, are difficult to identify. Below, we provide two broad categories. Within each of the categories, we provide examples. A complete listing is not possible as the benefits will vary according to the specific organization or departments involved.

1. Reduction in personnel (i.e., downsizing)

This is clearly the most obvious benefit and the one that is often cited – sometimes to the exclusion of all others. As an example, say the efficiency gains from the new system will

require three fewer staff. These staff positions can be eliminated, each with an estimated annual cost (salary and personnel benefits) of say CND\$50,000 each which results in a cost savings of CND\$150,000 per year. If the project is evaluated over a four-year time frame (due to the amortization schedule associated with the project), the savings could be further refined based on the present value of the human resources (HR) savings over that time.

A second cost consideration related to personnel requires no reduction in staff. The benefits in this case can be seen with improvements in quality, response or performance. However, these are best described in the second category.

2. Performance improvement

A second category of cost savings and benefits fall under the general heading of performance improvement. Unfortunately, the evaluation of performance improvement requires a measurement of current practices as well as future performances. The difference between these two observations represents the performance improvement (or decline). The measurement of current practices necessitates the development of standards and measures. If performance standards do not exist, then comparisons across institutions or time frames make no sense because the unit of measurement may vary in calculation or in composition. Furthermore, one reason for this lack of standards and measures is poor information systems. Consequently, performance improvement due to improved IS/IT is a very difficult component to integrate into the calculation of benefits in business cases.

Listed below is a sample of the type of measures that could be used (once again, inherent in the development of these standards must be an agreement regarding data capture and quantitative analysis).

- Reduction in time to get job done (i.e. cycle time);
- increase in percentage of tasks with no errors (improvement of quality);
- increase in staff satisfaction;
- increase in patient satisfaction;
- reduction in readmissions;
- reduction in length of stay;
- reduction in adverse events;
- improvement in balanced scorecard performance.

As an example, consider the treatment of asthma cases in an emergency department (ER). Incorporated in this treatment is the multiple components of cycle time: time waiting before seeing a provider; time with

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physician or other provider; time doing the diagnostic tests; and treatment time (incorporating treatment both in the ER and the training required to perform follow-up treatment at home). To be able to calculate such a benefit, one would need to establish the standard of time calculation, the method of data capture and the system by which current measures could be generated and compared to historic values (or other benchmarks). Finally, a method for assigning a dollar value to the improvement is also required if benefits are to be ultimately compared with costs.

Another perspective is to consider an overall change in performance regarding criteria within a balanced scorecard. The concept of the balanced scorecard pertains to the philosophy that an organization delivery health care should be effective across measures within many dimensions – i.e. financially, patient and staff satisfaction, mortality. Perhaps overall combined benefits should be based on a dollar value relationship derived from a balanced scorecard improvement or decline.

Information systems are
needed to illustrate benefits of
information systems

In the health-care industry, the main premise of improved information systems is that it will help to increase productivity and improve effectiveness and efficiency. However, to justify a large expenditure on IS, one needs to illustrate that benefits (as discussed above) outweigh costs. To complete the circular argument, we need to create an information system, using standards and measures, to illustrate the improvements that can be gained from these information systems. The only way out of this endless loop is to begin the process somewhere; and the best place to begin is identifying standards and measures such as those in a balanced scorecard. Benchmarking in health care (through the use of balanced scorecard components) is currently filled with difficulties because of the diverse data-capture techniques and the various data-coding options (Leonard *et al.*, 1998). For the most part, hospitals now operate without clear, unambiguous guidelines. As long as this exists without intervention, then:

- 1 meaningful comparisons cannot be performed;
- 2 determination of the optimal process cannot be attained.

Consequently, a pursuit of standardization is imperative if we are to heavily invest in IT

and effectively adopt IT. This would then allow for the development of a forum to begin to structure reasonable standards, benchmarks and objectives. Unfortunately, we need the IS first to demonstrate that it is cost-effective to do so. The ultimate recommendation, then, is that research must begin to apply the business case methodology to information system needs in health care.

The need to build business cases and to justify IT expenses has been well-documented (for example, see Pawola and Klineman, 1996). In a recent study (Leonard and Keller, 1998), when comparing performance internally across other Diagnostic Imaging (DI) departments or areas, or externally across other hospitals, it was quickly realized that few standards exist regarding performance measurement in this discipline. The ability to see a long-term objective being realized (accurate performance measures) provided enough motivation for the DI users/managers in nine hospitals throughout Canada to begin work on key standardized performance indicators for DI departments. However, at present, we are far from readily measuring IT effectiveness gains and incorporating them into the listing of benefits within a business case structure due to a lack of data standardization.

The Quality Index

It is the objective of this paper to develop an “effectiveness” or “impact” measurement tool for a CHIN or Community-Based Health Delivery System. This tool must be dynamic in monitoring changes in service delivery in the system. An integrated performance-based model of understanding the relationship of financial inputs and clinical outcomes is required. Here, a “Quality Index” supported by community and institutional information is proposed and is based on key indicators and measures of quality. It is hoped that the quality measures introduced herein will begin to measure the true effectiveness derived from improved efficiency through effective IS.

The Quality Index put forth in this paper contains only three indicators. A realistic index will and should contain more indicators. However, for presentation purposes, it was decided that the discussion centers only on a few key measures in order to illustrate the process and significance. The significance of this index in establishing benchmarks in a system that is being reformed cannot be overstated. In the absence of such a tool and of benchmarks, quality, effectiveness and efficiency will

remain only theoretical concepts and will not be operationalized in any meaningful way.

As stated, we wish to develop a Quality Index that measures true impact of effective information systems throughout the entire CHIN. As a result, the indicators should reflect change across a number of health-care providers within the CHIN and in a number of areas. Below, we list the three indicators to be evaluated:

- 1 home care approval time;
- 2 reduction in length of stay (LOS) for specific diagnosis groups (for a single hospital);
- 3 reduction in average length of stay (ALOS) (across all of the hospitals).

The calculation of the Index requires the establishment of three benchmarks within the CHIN (Leonard, 1995). The first benchmark represents the worst-case scenario and receives zero points. The second benchmark represents the best-case scenario which is the full achievement of realistic goals within the short term and this value receives a maximum of ten points. The third benchmark establishes an industry average which is usually somewhere between the first two benchmarks and receives three points. Points are then assigned to the CHIN's performance based on a linear extrapolation between the industry average and best case. Points are awarded for all three indicators and are totaled to provide an overall Quality Index. Below we list the ranges for, and provide a discussion on, these three criteria.

1. Home care approval time

This relates to the time that it takes to get a patient approved and accepted into a Home Care Program. If the introduction of IS initiatives has been effective, then approval time should decrease substantially. More applications will be able to be processed in a shorter amount of time resulting in patients being treated more efficiently. Further, accuracy levels should begin to increase due to the automated nature of the evaluation process.

This is an important measure and as the time shortens, so does the length of stay in the hospital (waiting for next steps and accumulating alternate level of care or ALC days). Using the Waterloo region CHIN as an illustration, consider the approval time was to be, at worst, five days and this performance would be awarded zero points. The best case would be within three hours and would be given ten points, and the industry average is one day or eight hours (and this would be awarded three points). Please see Table I to examine the number of points awarded for

Table I

Criteria for assignment of home care's performance scores

| Performance score | Criteria |
|-------------------|---|
| 10 | 100% of hospital cases have shorter approval time than industry average |
| 7 | Hospital ALOS is shorter than 75% of CIHI cases |
| 3 | Hospital ALOS is shorter than 50% of CIHI cases |
| 1 | Hospital ALOS is shorter than 25% OF CIHI cases |
| 0 | Hospital ALOS is longer than or equal to 100% of CIHI cases |

any improvement from the "expected one day approval time".

The CHIN's actual approval time for home care is approximately seven hours (or 0.875 days). However, for this index, a comparison to the industry average is warranted. The CHIN performance of seven hours is at the 60th percentile when compared to the industry average. Consequently, the score for this indicator is calculated to be: $[3+(7-3) \times (60-50/75-50)] = 4.60$.

2. Reduction in length of stay (LOS) for specific diagnosis groups

The length of stay within a single hospital is driven by many factors. These include items such as severity and type of illness, overall health, age and other recognized determinants of health. Assuming that we can group patients with like illnesses and complications, let us examine a worst, current and best case to be ten days, three days and one day, respectively. Table II shows the criteria used for assigning the performance scores. Here, we compare a

Table II

Criteria for assignment of a single hospital's performance scores

| Performance score | Criteria |
|-------------------|--|
| 10 | 100% of hospital cases have shorter LOS than industry average |
| 4 | Over 50% and less than 100% of the hospital's cases have shorter LOS |
| 3 | 50% of the hospital's cases have shorter LOS than industry average |
| 2 | Over 0% and less than 50% of the hospital's cases have shorter LOS |
| 0 | 0% of the hospital's cases have shorter LOS than industry average |

single hospital's LOS distribution to the industry average.

In one hospital within the CHIN, we observed a performance of 2.5 days which is calculated to be at the 56th percentile. The score representing this performance is: $[4+(10-4) \times (56-50)/(100-50)] = 4.72$.

3. Reduction in average length of stay (ALOS)

As opposed to the above indicator where a single hospital's performance is compared to industry averages, here the average across all CHIN hospitals is now compared to the industry. The scoring detail is presented in Table III.

This CHIN had an average that placed them in the 87th percentile. Consequently, the score is calculated to be: $[3+(9-3) \times (87-50/100-50)] = 7.50$.

Total Quality Index

The Total Quality Index is a straight arithmetic average calculation from the three components. One can think of this value as a percentage in the sense that the CHIN has achieved 56.1 percent of its objective which is to be at the 100th percentile for all measures. Another perspective is to examine the performance to the industry average. If a CHIN performed precisely on the average, then its score would be 3.00. A score of 5.61 can then be seen as an 87 percent improvement from the industry average. A summary of the performance measures is provided below in Table IV.

The actual number of the Index is similar to the actual performance measure – in, and of itself, they have no value. However, when compared to other CHINs or to historical

Table III

Criteria for assignment of CHIN performance scores

| Performance score | Criteria |
|-------------------|---|
| 10 | CHIN ALOS is shorter than 100% of industry cases |
| 9 | CHIN ALOS is shorter than 50% but not shorter than 100% of industry cases |
| 3 | CHIN ALOS is shorter than top 50% of industry cases |
| 1 | CHIN ALOS is shorter than 0% but not shorter than 50% of industry cases |
| 0 | CHIN ALOS is longer than or equal to 100% of industry cases |

Table IV

Summary of performance measures

| Criteria | CHIN performance score |
|----------------------|------------------------|
| 1. Approval time | 4.60 |
| 2. Reduction in LOS | 4.72 |
| 3. Reduction in ALOS | 7.50 |
| Total Quality Index | 5.61 |

values, the implications can be significant. For example, in the ALOS for the CHIN (3 above), the CHIN's actual average was not stated, just its percentile performance. (That is not to say that much effort is not needed to determine standards and operating procedures so as to calculate the ALOS for the industry or comparison group, as already discussed herein.) This then requires the ability to establish the percentile, further requiring the contribution from other organizations and CHINs.

To date, the Quality Index for the Waterloo CHIN is only in preliminary operation. The next step is to expand the Index to include more indicators. Once that has been resolved, operationalizing the calculation of the Index is required. It is hoped that this process of developing the Index will illustrate two clear facts:

- It is extremely difficult with the current IS to calculate performance measures – measures which all agree are vital.
- It is very important to measure the value that information can provide – so as to justify previous, and argue future, IT investment.

Hopefully, both of these findings should provide enough incentive for the group to move forward with IS integration.

Dollar value

As stated, a main objective of this paper was to investigate the IT benefits gained from new technology. This ultimately requires not only the measurement of performance but also quantifying it in some "business case" framework. In this Quality Index, the different criteria require different quantification. For instance, length of stay "savings" can be estimated more readily than shortening the home care approval time. As such, we argue that the calculation should focus on the Index itself – i.e. every one point improvement over three is worth CND\$100,000 in reduced patient costs and improved health over the course of one year. The Waterloo CHIN could then argue that the IT investment has yielded a savings of CND\$261,000. At this time, the actual savings

have not been determined and, as a result, this is only an example for calculation and interpretation purposes. What is important is that evaluation of the Index is not complete until the financial implications are considered.

Discussion

In this paper, we create a set of quality measures that can be used to evaluate the effectiveness of improved information systems in health care. These measures are comprised of standard performance statistics in order to insure widespread applicability. This Quality Index will serve two purposes:

- 1 motivate CHIN partners to begin the journey to a truly integrated network; and
- 2 assist in the ongoing management of the CHIN by providing quality indicators in a relevant working environment.

It should be reiterated that this Index is not complete and, as such, we do not advocate using "as is". The focus should be more on the process and the need for quality and outcome performance of IT than on the actual scores. Ultimately, there needs to be more of a link between IT investment and the improved efficiency and effectiveness that results. It is hoped that this presentation will assist in moving the industry ahead.

In order for the Quality Index to be fully implemented, some limitations must be removed. First, data capture must be standardized and accepted. Secondly, training and education must play a significant role in the development of management reports and summary documents. This education and support initiative is the key as it interacts directly with the perceptions and expectations of all the constituents (all internal and external groups) regarding communication of new ideas and the ability to effect change in the organization. Finally, one of the main difficulties is that organizations equate computers with information systems on a one-to-one basis. Information systems, however, are much more. Obtaining the correct reports and generating the appropriate measures – on a routine and ongoing schedule – is also the role of IS; but this role must be performed through a cooperative effort between user/manager and the IS liaison.

This paper does not describe the effect of implementing this type of report on subsequent performance. We leave that discussion for further research. However, a recent study in the United States conducted by Conrad and Maynard in 1996 explored the

impact of effective information in managed care on hospital efficiency. The findings indicated that sharing "resource-use" information with clinicians was one of three key factors in reducing cost per hospital discharge. When hospitals provided condition-specific "cost-per-stay" information to the clinicians, this resulted in anywhere from a 12 to 27 percent lower cost than in those hospitals that did not provide such information. The demand for information regarding length of stay and other cost surrogates will continue to grow as more comparisons on LOS are made in an attempt to cut costs. This paper presents a type of analysis and the development of measures that can be truly representative of how organizations are actually performing – in isolation and, more effectively, when compared to relevant benchmarks.

It is very difficult to change something that you cannot manage; to manage something you cannot measure; to measure something you cannot see. However, with the proper information system and benchmarks, change is possible. Benchmarking would add to the change process due to the fact that additional health providers would eliminate (by creating standards) performance anomalies. Clearly, improvements in efficiency will lead directly to lower costs and higher cost savings. As appropriate information and feedback are necessary conditions for improving efficiency, identifying standards for performance measure is critical.

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