

Healthcare Data Warehousing Evaluation Study

Discussion of Findings and Conclusion

April 2014

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“You might ask: “Why evaluate?” For years, health IT has been implemented with the goals of improving clinical care processes, health care quality, and patient safety. In short, it’s been viewed as the right thing to do. In those early days, evaluation took a back seat to project work. Frequently, evaluations were not performed at all – at a tremendous loss to the health IT field. Health IT projects require large investments, and stakeholders increasingly are demanding to know both the actual and future value of these projects. As a result, we as a field are moving away from talking about theoretical value, to a place where we measure real value. We have reached a point where isolated studies and anecdotal evidence are not enough – not for our stakeholders, nor for the health care community at large. Evaluations must be viewed as an integral piece of every project, not as an afterthought.”

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Executive Summary

In the fall of 2013, an empirical study was conducted in collaboration with the Healthcare Data Warehousing Association that had three objectives:

1. Investigate the state of health data warehousing evaluation;
2. Test an evaluation model and toolkit intended for use by healthcare organizations; and
3. Investigate the use made of health data warehousing to improve healthcare efficiency.

By enlisting the participation of highly representative organizations and gathering the input of very skilled and experienced respondents, the study brought valuable insight into a topic never investigated before. Moreover, the quality of the sample and respondents' contributions made it possible to go above and beyond the initial exploratory objectives and add explanatory value to the research.

State of Health Data Warehousing Evaluation

The study established that the system is not formally evaluated and that informal assessments, when performed, do not involve consistent methods or standardized measures. Neither are Critical Success Factors taken into consideration. This finding appears to explain why a literature review on the topic returns so few publications. The research found that evaluation was seldom perceived as necessary and, more notably, is a concept for which comprehensive frameworks are lacking.

Model/Toolkit Testing

The study enabled the testing of the evaluation model and toolkit developed earlier, and produced a gap analysis that compared and contrasted the findings with the proposed model/toolkit.

Use of Health Data Warehousing to Improve Healthcare Efficiency

The study also showed how, from patient throughput to productivity tracking and cost optimization, data warehousing significantly contributes to improving the efficiency of healthcare systems. It demonstrated the

positive impact of the technology in medical, clinical, and research areas. The study reported impressive accomplishments in the area of process improvement, and, equally importantly, indicated how data warehousing enables such improvements.

Explanatory Value of the Research

The data collected over the course of the empirical study added an explanatory value to the broader research by:

- Identifying key determinants which reinforce the need for evaluation;
- Identifying some of the reasons why evaluation is not performed;
- Providing insight into what takes place in lieu of evaluation; and
- Indicating whether alternatives are considered for the future.

Research Implications

The research has implications at four levels:

• Healthcare Organizations

By adopting the proposed evaluation model/toolkit, healthcare organizations would acquire the means to perform objective assessments internally. In doing so, they would gain actionable insight into resources optimization; increase return on investments, accountability and transparency for all stakeholders; strengthen their strategic capability to control their environment; and generate system improvements which would expand net benefits for the technology as a whole and for their organizations.

• Industry

Even though evaluation is increasingly considered by the industry, the tendency remains to focus on technology as a panacea which results in market fragmentation and lack of cohesion. The adoption by the industry of sound evaluation practices holds the potential of a more adequate and effective way to reconcile supply and demand as well as meet both current and developing needs.

- **Research**

The research implications extend beyond data warehousing. Evaluation models and toolkits should be tailored to other major healthcare information systems. This would result in an overall evaluation portfolio which would increase return on investments at the organizational level while providing factual evidence for the analysis of the progress made towards healthcare reform.

- **Need for Result-oriented Cooperation between Actors**

Paradoxically, in an era characterized by the ability to share massive amounts of information in record time, effective and result-oriented cooperation between actors remains challenging. Far from being an idealistic aspiration, such cooperation is the only effective way of enabling benchmarking, the dissemination of best practices, and the adoption of standards.

Discussion

1. Addressing the Research Questions

1.1. Exploration Research

Exploration was the primary objective of the empirical study and was achieved by using semi-structured interviews to address three research questions starting with “What is the state of health data warehousing?” The study provided an unequivocal answer to this question. The system was not formally evaluated nor was its evaluation perceived as necessary. Furthermore, Critical Success Factors (CSFs) were not taken into consideration. When performed, informal assessments did not involve consistent methods or standardized measures. These results may well explain why a literature review on the topic returned so few publications.

The next major finding of the research is that, not only in practice but also from a theoretical standpoint, the concept of evaluation itself is very seldom considered with regard to health data warehousing. The representation in a word cloud (Figure 1) of the interviews’ top 15 words of four letters or more symbolizes this finding.



Figure 1 – Word Cloud of top 15 words

Even though the study focused on evaluation, the word cloud does not include any term pertaining to it.

When added to the list (Figure 2), the interviews’ mentions of evaluation, measure, assessment, monitoring, and standard all rank at the bottom. It is noteworthy that there were only two occurrences of the expression “best practice.” The distribution of evaluation terminology (Figure 3) confirms this pattern. The respondent who referred the most to evaluation terminology (R12) did so less than 1% of the time. In light of these results, it is not surprising that respondents experienced difficulty in relating to the concept of evaluation when they were asked to describe its use.

This in turn indicates how evaluation, as it relates to health information systems in general and health data warehousing in particular, remains an area for which comprehensive theoretical frameworks are lacking. The absence of frameworks means there are few, if any, guidelines to assist professionals in conducting sound and objective assessments, and ultimately results in evaluation not being performed.

Using the same exploration process, the empirical study also achieved the objective of answering the third research question, “How is data warehousing used to improve healthcare efficiency?” The study showed how, from patient throughput to productivity tracking and cost optimization, data warehousing significantly contributes to improving the efficiency of healthcare systems. It equally showcased the positive impact of the technology in medical, clinical, and research areas.

The research reported notable accomplishments in the area of process improvement, and importantly it indicated how data warehousing enables such improvements.

Top 5 Evaluation Terms

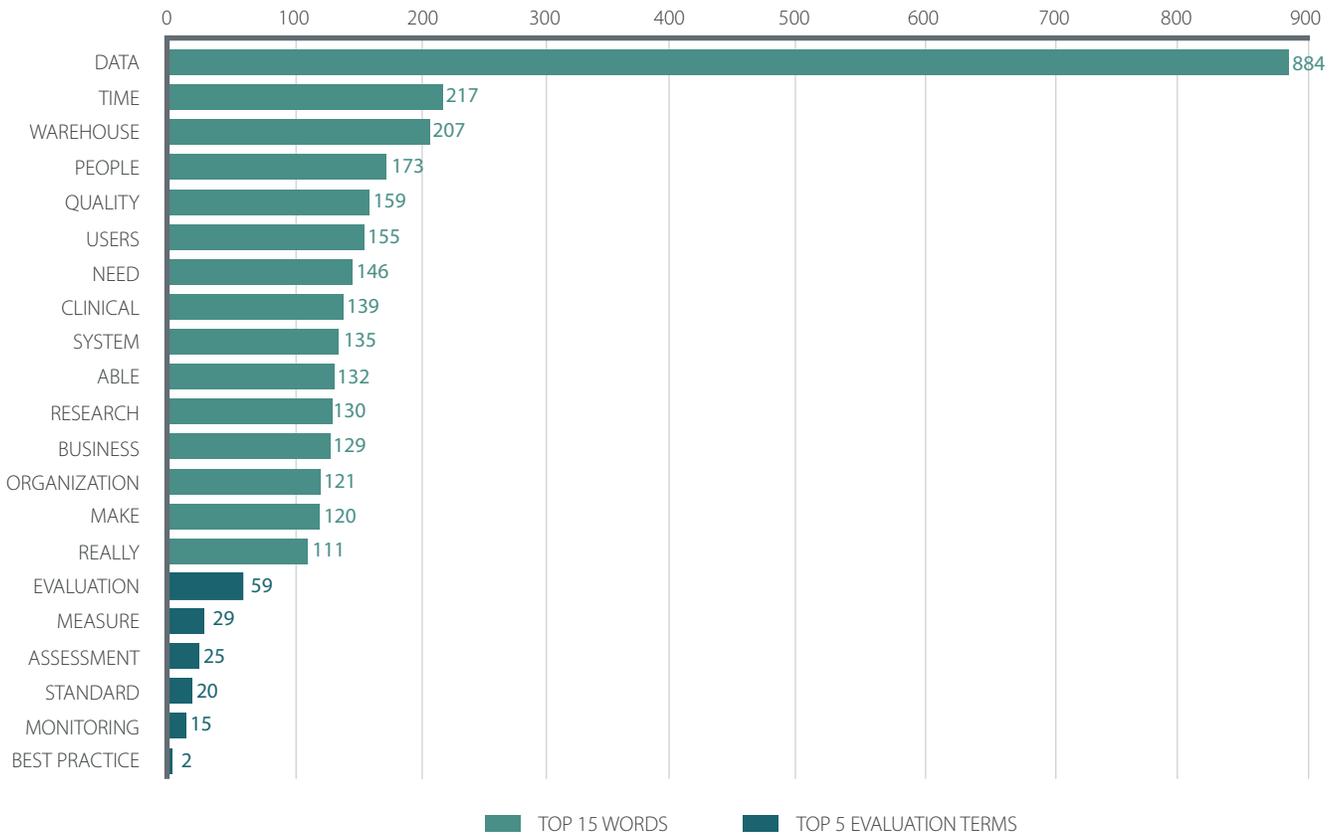


Figure 2 – Top 5 Evaluation Terms

Distribution of Evaluation Terminology

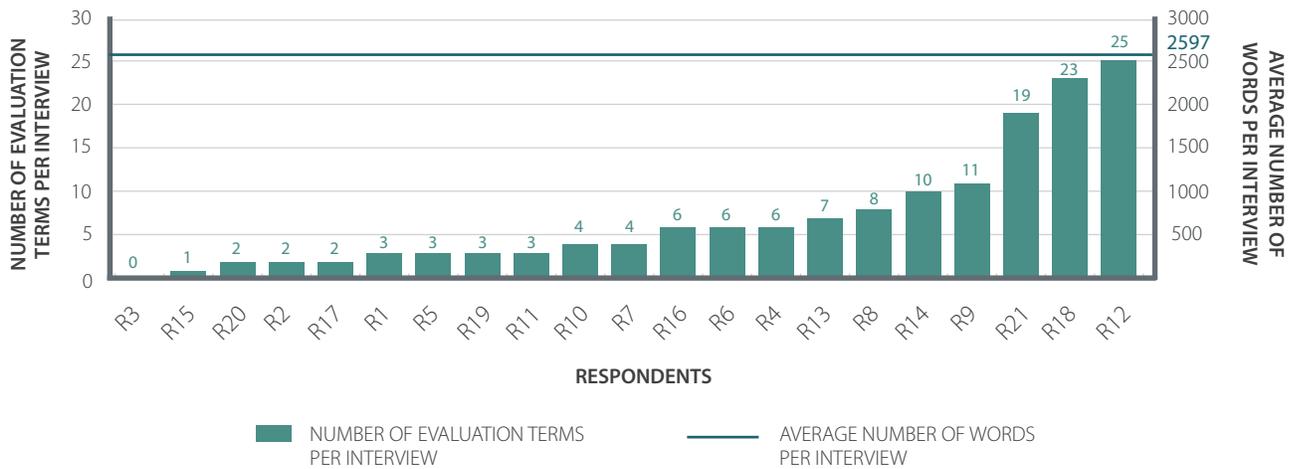


Figure 3 – Distribution of Evaluation Terminology

From 1995 to 2005, productivity growth in the private industry was estimated at 2.5% annually. In healthcare, education, and social assistance it accounted for -0.2%. What characterized private industry productivity during that period was not the production of new goods but the generation of better ways to organize production and manage distribution and sales. Healthcare systems, on the other hand, were marked by little to no organizational innovations (Culter, 2010). A paradigm shift has since occurred that is transforming how healthcare systems operate. Even though innovation is most often associated with products it can also apply to processes, which can lead to major shifts in organizational performance. The research offered multiple examples of such transformation. All participating organizations were innovating through process. In doing so they were no longer focusing on providing the best possible care to single patients but rather to all of their patients. They were following a comprehensive approach based on process rather than a fragmented one based on tradeoffs between care and other outcomes. Achieving such a comprehensive perspective relies heavily on the production of data analytics and business intelligence to support the monitoring, in-depth analysis, and forecasting of all necessary indicators. The research demonstrated that data warehouses are the best available systems to generate the needed information. Not only were they capturing data from all individual systems to provide a “single version of the truth,” but they were making it available in customized and usable formats.

If innovation through process is based on standardization, the latter aims primarily at reducing variation. All participating organizations offered numerous examples of how data warehousing contributes to this effort. It was achieved in terms of the processes involved at the patient visit level and also at the medical, clinical and research levels with aspects such as patient flows, procedures, treatments, and discharge.

While motivated by an ongoing quest to improve the quality of care, the above-mentioned transformation is also an attempt to curtail ever-increasing costs. Nonetheless, it is important to note that, despite the urgency to address the financial viability of healthcare systems, the emphasis is not placed directly on financial

aspects. The research confirmed this. Respondents did not report initiatives as intended to reduce costs but rather as improvement projects which eventually translated to cost reductions. The rationale behind this approach is that proper understanding of the inefficiencies at play must be gained first. This conditions the improvement of healthcare delivery which is, in turn, a prerequisite to lowering costs. As confirmed by the research, a multitude of improvement initiatives are underway. However, if similar projects were occurring across all participating organizations, many projects were different, which raises the question whether all initiatives are created equal, i.e. whether they really serve the purpose of improving care for all vs. single patients. The only way to address this question is through evaluation. Whether at the data warehousing or project level, however, participants did not report the existence of a formal evaluation process meant to address the adequacy of improvement initiatives.

Similarly, even though targeted indirectly, attempts to improve patient safety and quality are also attempts at strengthening accountability and transparency. Here, because the emphasis is on care improvement, the attempts are seen primarily as concerning clinical and medical areas. However, they also apply to and will increasingly be the norm for all ancillary services, including information technologies. If the transformation of healthcare systems from volume- to value-based relies heavily on the deployment of information systems, their “meaningful use” is equally essential. Whether such use is achieved and optimized can only be determined through evaluation. In this regard, the research unveiled what can be called the paradox of health data warehousing evaluation – or the lack thereof. The technology was said to be at the center of considerable efforts to improve performance and reduce costs. It was described as a part of and a contribution to a data-driven culture based on measures. This is not only the central pillar of process improvement but also the prerequisite for sound and objective evaluation. However, the effort was not reflexive, i.e. it did not apply to data warehousing itself. The same data-driven culture was not found around the system, i.e. its evaluation was not perceived as necessary. Very few metrics were applied to the technology and fewer, if any, were defined with reference to standards and best practice, be it to assess

its use, its cost or the quality of its output. Similarly, benchmarking was almost non-existent. The technology seemed to follow the very same volume-based pattern that improvement initiatives were seeking to change in the clinical and medical areas. While the assessment of performance, efficiency and effectiveness (both technologically and in terms of use) received limited attention, in several instances increasing resources continued to be allocated to the deployment of newer technologies whose maturity was still being questioned.

1.2. Model/Toolkit Testing

The empirical study also made it possible to achieve the second objective of the research, i.e. to partially test the evaluation model and toolkit developed earlier. In doing so, the study addressed the second research question, “How should the evaluation of health data warehousing be conducted?” Section 3.4 compares and contrasts the research findings with the proposed model and toolkit.

1.3. Explanatory Dimension

The data collected over the course of the empirical study enabled the researcher to go above and beyond the objectives set forth by the research proposal. It added an explanatory value from a twofold perspective.

On one hand, three key determinants of health data warehousing were identified which reinforce the need for evaluation.

Specificity of health data.

Compared with other sectors, the data found in healthcare is first and foremost voluminous. One respondent offered a description of this characteristic:

“In healthcare it’s the sheer volume of tables and columns that you have. We don’t have billions of encounters but we have lots of columns that describe that encounter and that patient.” (R14)

Health data is not only voluminous, it is heterogeneous. It is patient-centric as it relates to patients. It is aggregated when relating to utilization and resource management. It is transformation-based when pertaining to decision support for management or clinical purposes. It is comparative

when applied to health services research, outcomes measurement and population health. As a result, data sources are numerous as well (from Electronic Health Records to billing, scheduling, laboratory or imaging sources) and usually relate to specific health domains which tend to constitute silos that are hard to integrate in the data warehouse. The evaluation of system and information quality is thus particularly critical for health data warehousing.

Constantly evolving nature of health data warehousing.

This aspect cannot be emphasized enough. It encompasses an array of factors from the integration of technological advances to adjustments to internal and external environments. This has a profound impact on the system by keeping it in a constant state of flux. The changes currently occurring as a result of healthcare reform further increase such volatility. This reinforces the need to make the assessment of organizational factors an intrinsic part of the evaluation model and toolkit.

Health data warehousing raison d’être.

Nearly 40% of respondents deemed it possible to obtain similar results without the data warehouse while a majority (86%) saw the added value of the system in its ability to enable integration, fast delivery, and easy manipulation of data as well as the unveiling of issues otherwise left unaddressed. This finding informs evaluation in a critical manner since it helps target the areas where key net benefits can be expected.

On the other hand, the research unveiled some of the reasons why evaluation is not performed, providing insight into what takes place in lieu of evaluation, and indicating whether alternatives are considered for the future. Section 3 presents a detailed discussion of these findings.

2. Research Limitations

As with any exploration study, three major limitations affected the research: credibility, dependability and transferability.

2.1. Credibility

This refers to the ability of the researcher to acquire a proper impression of the investigated topic. It is threefold and encompasses:

- The potential effect of the observer's presence during the study;
- The potentially distorting effects of the observer's perceptions and interpretation; and
- The observer's limited capacity to account for each and every aspect of the topic under investigation.

The researcher addressed the issue of credibility by discussing generalization concepts with respondents to confirm the plausibility of these concepts. Multiple exposures to content minimized the risk of distorting effects. From the interview sessions to their transcription, coding, and analysis, the content was reviewed in various forms, from various angles, and at various points in time. Additionally, potential biases were compensated for by paying particular attention to evidence that contradicted observations.

Having ensured the recruitment of a sufficient number of respondents increased the research validity as well. In the absence of consensus on what constitutes a sufficient sample size, qualitative research relies on the principle of saturation, i.e. data collection is pursued until it can be determined that no new data is forthcoming. However, there is no consensus on how to establish when such state is reached. The empirical study followed the principle of saturation and the latter was deemed reached at the 21st interview. The decision was made based on the following considerations:

- There is a general agreement that, when used for qualitative research, samples should not be smaller than 15 (Bertaux, 1981). The research met this requirement.
- It is also commonly accepted that as long as data is collected there will always be new content emerging but that the added value of new content inevitably decreases over time. It is left to the discretion of researchers to assess this trend. To minimize the arbitrary nature of the assessment, researchers must proceed with discipline and analyze data as it is collected in

order to determine the cut-off point (Strauss & Corbin, 1998). The research strictly conformed to this methodology. In doing so, it was established that from the 15th interview on, the return on new content was continuously and significantly diminishing. By the 21st interview, very little distinct content was found and for only a few isolated concepts.

- It is also recommended that saturation be determined with reference to the coding scheme and the chronology of the codes' development (Guest, Bunce, & Johnson, 2006). All main codes were developed by the 14th interview. Seventy four percent of the sub-codes were developed over the course of the first eight interviews and only 2% were developed over the last five.
- The value of qualitative data is a product of the interviewer's ability to elicit respondents' contributions and thus relies on his/her skill level and experience. It can be reasonably expected that an experienced interviewer will collect more valuable data faster (Guest, Bunce, & Johnson, 2006). The fact that the researcher was a seasoned professional with prior academic background and professional experience, including the practice of qualitative methods, corroborates this expectation.

Lastly, a separate edition of the research design and findings was specifically assembled and disseminated to all respondents. In doing so, participants were given the opportunity to review all materials and provide feedback on areas possibly misrepresented or dealt with in an erroneous manner. Those respondents who provided feedback approved of the accounts made of their contribution and agreed with the research findings.

2.2. Dependability

This limitation refers to the replicability of observations and to the ability of another researcher to generate similar observations when repeating the procedures under similar conditions (Horsburgh, 2003; Miles & Huberman, 1994). To ensure dependability, the research design was thoroughly documented and included a complete description of all procedures used to conduct the empirical study.

2.3. Transferability

The data produced by exploration research is most often textual. The research method produces “text” which even though analyzed does not lend itself to statistical analysis. This in turn bears the risk of inconclusive results which cannot be generalized. By applying the principle of saturation throughout the analysis process to a highly representative sample, the risk of inconclusiveness was successfully minimized. Moreover, by enlisting the participation of the Healthcare Data Warehousing Association, the largest professional organization for the technology under study, participants’ recruitment was achieved under optimal conditions. This conferred a high degree of relevance on the sample. The ability of respondents to provide pertinent information on the topic was remarkably high. Since they were based on a rigorously tailored structure, i.e. one that mirrored the research questions and involved a guide but yet offered respondents the opportunity to expand on any area as they saw fit, the interviews themselves were conducted under equally advantageous conditions (Horsburgh, 2003; Miles & Huberman, 1994).

The major limitation of the research pertains to the generalization of its findings. As opposed to the statistical generalization offered by quantitative studies, generalization based on qualitative research is situational in nature, i.e. whether results can be extended to individuals in similar situations using the theory developed within a particular study (Horsburgh, 2003; Miles & Huberman, 1994). If the research meets such a prerequisite, a series of limitations must be considered.

Since they were drawn from North American healthcare organizations and therefore reflect their professional contexts and the views shared by their personnel, the research findings may not be generalizable to other countries, particularly those employing a different healthcare system. Even though highly representative, the organizations surveyed for this study belonged to a limited number of localities. Care must thus be exercised in generalizing the results within North-America. Moreover, the sample included only hospitals, medical centers, and health systems. Generalizing the

research results to all healthcare organizations may not be appropriate, particularly in the case of state and federal departments of health or specialized segments of the industry. Similarly, only one respondent in each organization was interviewed. This raises the concern that a single respondent’s view may not reflect that of an entire organization. Additionally, most of the systems in use were either still at a fairly early stage in the adoption process or undergoing substantial redesign. As these systems evolve, the opinions which respondents have of their evaluation may evolve as well.

If taking these limitations into consideration is essential, it must also be stated that the benefits of the research, i.e. the availability of actionable information on a topic never before investigated, outweigh such limitations. Unless and until they are contradicted and/or augmented by practice and additional studies, the research findings represent the only body of knowledge solely dedicated to the evaluation of health data warehousing. The next sections provide a gap analysis and compare and contrast the research findings with the principles of formal assessments set out in the proposed model and toolkit.

3. Gap Analysis

3.1. Evaluation vs. Monitoring

Evaluation was a concept which respondents experienced difficulty in relating to and, was often confused with monitoring. As the acronym “M&E” indicates, monitoring and evaluation are usually associated. However, even though related, they are not identical. The following table compares their respective characteristics.

While monitoring provides input on a limited number of variables, evaluation provides the comprehensive link to the overall strategic framework including corporate vision and values. This is of particular importance in the case of data warehousing since the system impacts decision making and efficiency improvement across entire healthcare organizations.

Table 1 – Monitoring vs. Evaluation

MONITORING	EVALUATION
DEFINITION	
Monitoring is the tracking and supervision over time of ongoing activities.	Evaluation is the systematic assessment of performance, at the project or corporate level.
OBJECTIVE	
Monitoring aims at guaranteeing that activities are on course and executed within budget.	Evaluation aims at comparing impact against agreed strategic plans to determine the effectiveness, efficiency and sustainability of interventions.
SCOPE	
Monitoring is confined to the progress of activities. It involves process analysis and the control of activities to ensure proper management.	Evaluation covers the entire results chain from pre-established targets to achieved accomplishments in order to inform decision making. It not only includes input and output assessment but causality analysis to determine the degree to which achievements are accomplished and how.
TIMEFRAME	
Monitoring occurs between project initiation and implementation.	Evaluation can be either formative and take place during the development and early implementation phases, or summative and occur at the end of an operating cycle. Both methods are necessary in order to inform short- and long-term decision making.

3.2. Evaluation vs. Project Management

M&E is an integral part of program management. It is commonly used in most sectors of the economy but not applied to information technology. With regard to the latter, instead what is performed is “Monitoring and Controlling,” i.e. one of the five stages of project management which consists in tracking progress and identifying gaps with initial plans (monitoring), and initiating corrective action to meet the objectives of a project (controlling).

This definition may help explain why respondents often mentioned that evaluation was not requested. It is not considered a part of project management. Similarly, it could explain why respondents often presented evaluation as justified by the existence of concerns or complaints. This reflects the “controlling” stage of project management, i.e. the emphasis on remediating project gaps.

The project-based approach was also reflected in the case of improvement initiatives supported by data warehousing. The existence and management of the technology were oftentimes defined by these initiatives.

This also profoundly alters the system’s evaluation and in some instances, renders it nearly irrelevant.

When assessed, the data warehouse is evaluated with regard to the individual projects it supports, not in and of itself, i.e. its effectiveness, its performance, the usability of its front-end tools, or how well it serves strategic objectives at the corporate level. One respondent clearly indicated this dependency:

“You don’t so much demonstrate the value of the data warehouse in a vacuum, what you need to demonstrate is the success or failure of particular initiatives. They succeed or fail in part based on the ease and completeness of the access to the data needed to support them. We are not selling the data warehouse globally we’re selling the value of the data warehouse for particular initiatives.” (R14)

As a corollary, the onus to evaluate is on the owners of the initiatives. This onus risks bypassing data warehousing factors if they are not part of the evaluation conducted at the project level:

“In various projects they’re better at identifying the ROI and the benefits and publishing that within their area of responsibility.” (R21)

One area, users' needs assessments, logically calls for an initiative-based approach. However, in terms of evaluation, it raises the question whether the collection and analysis of these assessments involve processes that are at risk of redundancy across initiatives. Respondents emphasized the repetitive character of these processes but did not indicate any potential for streamlining:

"We do this over and over for every project and then we go through an architecting [sic] design and development to meet those user needs." (R11)

When associated with resources, the evaluation of users' needs assessments creates yet another paradox. Most of those respondents who deemed the available resources to be sufficient also stated they had not met the requirements identified by the needs assessments. This contradiction somewhat weakens the statement of sufficiency. Can resources really be sufficient if a fundamental step of the project life cycle is not, or is only partially, addressed? At the very least, the contradiction seems to confirm the volume- vs. value-based analogy made in section 1.1., that resources are spent regardless of the products-to-costs ratio.

As an evaluation factor, users' needs assessments are particularly valuable because they lend themselves to the derivation of metrics which both measure whether targets are achieved and determine where improvements are needed. In the context of the research, they enabled the testing of an additional assumption: organizations that hired external consulting firms to conduct needs assessments were those where users' needs had been met. Based on the data collected over the course of the empirical study, this assumption was not confirmed. On the other hand, several respondents reported the need to stay abreast of the latest technological advances though the use of their current systems had not yet been optimized. Suffice it to say that this is not specific to health data warehousing but pervasive throughout the information technology industry and equally applies to the latest smartphone model. This again typifies the volume- vs. value-based analogy. The recourse to external consulting firms follows a similar pattern, though based on a different rationale: the assumption that consultants alone, by the mere fact of being external to the organization, can provide expert and objective advice.

A discussion of these issues goes well beyond the context of the research. However, they were brought up by several respondents and seem well worth mentioning. More importantly, they represent an opportunity to highlight one of the long-term byproducts of evaluation, i.e. the increased awareness gained from comprehensive assessments can increase autonomy and control over business goals. This concept was summarized by one of the respondents in the following terms:

"Up until your conversation, the idea of evaluating a warehouse was typically done by a consultant or a vendor. Hearing of an objective evaluation framework that isn't being done to espouse a particular consultant or vendor, I'm very curious to see how that evolves so that it gives a group a fair chance at evaluating things objectively without somebody trying to sell something at the same time." (R12)

3.3. Evaluation vs. Recognition, Perceived Value and Success

When asked to describe what evaluation should entail, respondents often referred to the notion of recognition. Instead of defining assessment factors, they would state that the existence of and results obtained from the system were acknowledged and appreciated.

As one respondent candidly said:

"We get a pat on the back." (R5)

Along with recognition, "perceived value" was also invoked to define evaluation. The adjective perceived has its Latin roots in *per*, meaning "thoroughly," and *capere*, meaning "to grasp." In contemporary English, perceived means mentally grasping, sensing by instinct rather than fact. Unlike evaluation, perceived value is subjective in nature. It does not involve correlation with measured targets. It does not serve the broader purpose of determining what outcomes are and the conditions under which they are achieved.

In addition to recognition and perceived value, success was another concept commonly invoked by respondents to qualify the outcomes and/or impact of the health data warehouse. The research referred to CSFs on multiple occasions but did not use them in the development of the model and toolkit as CSFs appear to be essentially based on anecdotal evidence and do not offer insight into how information systems can be improved.

The research also made repeated reference to the efforts of DeLone and McLean (1992, 2002, 2003) in providing a comprehensive success model based on the identification and testing of operative independent variables, and critiqued the relationship established by the authors between success and effectiveness, the lack of emphasis on the System Development Life Cycle, and the lack of guidance in determining whether success is achieved.

The explanatory value realized by the empirical study led to further questions about the notion of success itself and to posit the following twofold definition:

1. Success is the substantial attainment of predetermined net benefits measured by operationalized factors derived from the dimensions and components of an information system according to the business objectives set forth for the system at the corporate level in pursuit of an organization's mission.
2. The achievement of success cannot be established in absolute terms but rather by applying operationalized evaluation frameworks on a case-by-case basis, i.e. by evaluating each information system with regard to the environment in which it is deployed and/or used.

In practical terms, success is not achieved as a whole but in varying degrees. This raises the question of how to measure the degree of success and ultimately of the purpose of determining success. Evaluation, the assessment process leading to such a determination, is the only way to identify the extent to which success is achieved and how. It is the measurement of net benefits along with the explanation of how they were obtained that enables the discernment of needed improvements and opportunities for optimization, which is the purpose of evaluation.

The research posits that effective production of such analysis requires models to represent the dimensions, components and net benefits of the information system under evaluation. It also posits that models must in turn be translated into practical toolkits to operationalize the assessment. Moreover, toolkits must involve a ranking and scoring structure (since some factors are more

determining than others in achieving net benefits). After collecting and analyzing the necessary data, the evaluation process ends with the production of an overall score representing the proportion of attained net benefits and scores on individual factors which can be used to highlight priorities for improvement.

The next section compares and contrasts the research findings with the proposed evaluation model and toolkit, and provides suggestions as to the execution of the evaluation process.

3.4. Research Findings vs. Proposed Model/ Toolkit

Respondents seemed to have an intuitive understanding that assessments ought to be performed, but there appeared to be very little awareness of the meaning and purpose of system-wide evaluation.

One of the respondents suggested a refinement on the purpose of evaluation:

"Is there a metric that shows skilled and unskilled on one axis and aware and unaware on another axis? Obviously, you want to be skilled and aware. If you're unskilled and unaware there's no way to get better. In business that's failing, you're wasting money. If you're unskilled but aware, you can do two things. You can get better or you can stop doing that work, but it's hard to stay unskilled and unaware, it's a very uncomfortable place. Without evaluation, I think there are a lot of groups which risk being unskilled and unaware. The larger the business the more there is a risk that progress in data warehousing is measured only in terms of what is spent." (R12)

Indeed, the objective of evaluation is not to determine the amount of resources spent. That is done by tracking resources at the project management level. Evaluation demonstrates the measurable impact of the data warehouse on expected outcomes, i.e. net benefits, and their attainment through effective and efficient use of the system. Evaluation thus aims at informing decision making about the system by identifying the most valuable and efficient uses of resources. Most importantly, it does so by referring to the overall strategic goals set out at the corporate level. This is of critical importance for health data warehousing since the system serves multiple interests – operational, medical, clinical, and research – across entire organizations. Ultimately, evaluation is the key determinant for generating system improvement.

As with most healthcare improvement initiatives, evaluation leads to cost reduction and increased accountability and transparency for all stakeholders. Evaluation is the educative process that charts the two axes of awareness and skill suggested by respondent R12 in the quotation above. By not assessing against targets and indicators, the organization puts itself at risk of using resources to suboptimal ends, be it in financial, technical or utilization terms.

The research findings also confirmed the inherent complexity of the evaluation process. Several respondents qualified it as “difficult.” There are indeed challenges to health data warehousing evaluation. The complexity of the system and the heterogeneity of health data render their assessment particularly difficult. Evaluation methods vary depending on the factors under study. Quantifying the contributions of health data warehousing to corporate goals and health outcomes is not an easy task. Last but not least, resources must be allocated towards evaluation itself which is particularly challenging when formal assessments are not perceived as necessary. The overview of the state of health data warehousing evaluation also accounted for multiple areas for which improvements were needed. Even though identified, those needs were seldom, if at all, quantified and analyzed with regard to the entire results chain. They were however cited by respondents across most participating organizations, and so was the intuition that evaluation ought to be performed in order to address them. It would seem that the absence of formal evaluation is mainly related to the inherent difficulty of conducting assessments in the absence of guidelines. By setting up an evaluation framework the research afforded such guidance. By introducing a toolkit as a practical counterpart to this framework the research also suggested ways to considerably decrease the level of difficulty faced by healthcare organizations and perform the assessments more easily.

As part of the empirical study, respondents were given the opportunity to designate which factors the assessment should comprise. Beyond assessment criteria, this finding actually informed the ranking order of the evaluation factors. The top three criteria were costs and benefits analyses as well as support to the organization’s mission. The next three factors pertained

to the impact of the system, i.e. impact on patient care, the unveiling of issues otherwise unknown and financial impact. This was summarized by one of the respondents as follow:

“I think the evaluation isn’t does somebody match perfectly the Kimbal model or does the warehouse have all the latest technology, but I would say it’s the percentage of investment that is directly delivering on the most valuable component. It’s not just about evaluating information technology and business intelligence, it’s about evaluating the customer and knowing what the percentage of delivered results used is.”
(R12)

System infrastructure, utilization and the management of the system ranked in the middle of the distribution, while the bottom three factors pertained to data accuracy, quality, and latency.

It is important to note that respondents were not asked to rank order their criteria. However, they cited them by order of importance based on their experience with the system’s management in the context of their organization. Similarly, their choice of evaluation methods (monitoring, usage tracking, users’ surveys) was a reflection of the methods used in the context of project management. In contrast, the proposed model and toolkit are based on evaluation principles which provide guidance for the conduct of the assessment by defining all components and factors which are operationalized into metrics, and by assigning them the most appropriate method. In doing so, they offer a structure for a comprehensive evaluation that aims at informing decision makers why results are the way they are and designating areas in need of improvement. The model and toolkit also prioritize such needed improvements based on a ranking structure, not only with regard to strategic and organizational purposes but in direct reference with the dimensions of the system. This comprehensive approach guarantees the objectivity of the assessment.

4. Future Directions

The implications of the research should be considered with regard to healthcare organizations, the information technology industry and research. Implications should also be considered with regard to addressing the need for result-oriented cooperation between these three entities.

4.1. Implications for Healthcare Organizations

One of the respondents summarized the immediate implication of the research:

“As you go about your day to day thinking, your budgeting and your strategic decisions, if you know what an evaluation criteria looks like, just setting yourself up so that you know the answer ahead of time, as opposed to making decisions without the benefit of an evaluation framework. People are to be able to justify what they’ve done. It would be better if they had the framework upfront, so that it’s built in and the justification aligns to a framework as opposed to just a plea for a subjective value.” (R12)

By adopting the proposed evaluation model and toolkit, healthcare organizations would acquire the means to perform objective assessments internally. In doing so, they would gain actionable insight into resources optimization by taking stock in a systematic fashion of what is occurring and how. The empirical study provided examples of such areas which, if addressed, would lead to increased net benefits for the system and for healthcare organizations.

The extent of the contribution made by data warehousing to the improvement of healthcare efficiency cannot be emphasized enough. Through monitoring and control, organizations are already partially tracking some of the system’s key performance indicators. A formal assessment performed in a systematic fashion would create even more significant results.

The implications of the research go beyond data warehousing. Adjusted to other systems, the data warehousing evaluation model and toolkit could become a part of a much broader portfolio of assessments. Beyond generating additional net benefits across the entire information technology infrastructure, this would increase the strategic capability of healthcare organizations to control their environment. The healthcare sector is being impacted by a series of unprecedented changes the consequences of which are unfolding with a domino effect. The reform currently underway in the US heavily relies on information systems. A race against time is taking place with the information technology industry trying to supply the needed equipment on one hand, and healthcare organizations struggling to adopt them while having

to comply with the reform’s requirements on the other. Time pressure and the speed at which new products are introduced are adding unpredictability to an already volatile environment. Under such circumstances, decision making is inevitably hampered by issues and concerns the prioritization of which is increasingly difficult to establish. The availability of quantified measures of systems’ performance, effectiveness and efficiency would help alleviate such unpredictability, improve decision making, increase return on investments, and provide clear and distinct feedback to the information technology industry on needed technical improvements.

4.2. Implications for the Industry

Gartner Inc., a leading US information technology research and advisory firm, makes ample use of evaluation for its business intelligence consulting portfolio. For example, Gartner Inc. recommends measuring satisfaction with data timeliness, relevancy, accuracy and consistency. The ability to use data for business decisions is also part of the assessment process which is scheduled quarterly to address the evolving nature of business intelligence. The evaluation aims at discerning data quality issues that have the greatest impact on business goals and strategy in order to prioritize solutions.

If this practice is becoming more common, the message of the industry still remains focused on technology as a panacea. As well, the market is reaching unprecedented saturation levels with digitization products and solutions whose quality and integration are increasingly hard to decipher. Fragmentation and lack of cohesion in turn obscure the clarity demanded for sound strategies. For example, the industry impetus to utilize external sources of Big Data is seldom related to its trade-off, i.e. the diverting of resources which would otherwise be focused on the extraction and analysis of critical internal data.

According to a survey conducted by Gartner’s Executive Programs and published in January 2014, 42% of CIOs lack the necessary human resources to address the requirements of digitization. The survey also indicated that information technology budgets will remain unchanged or increase only slightly (0.2%) in 2014 (Gartner Inc, 2014).

While health information systems' budgets have increased tremendously in recent years, the sustainability of this growth pattern is coming under scrutiny. Less than half of those who participated in the empirical study indicated that they had sufficient resources. A limited capacity to meet the digitization demand with increased resources will inevitably curb the tendency to outsource, and instead shift focus towards the talent and expertise found in-house.

In such a context, the adoption of sound evaluation practices is equally relevant to the industry. It holds the potential of a more adequate and effective way to reconcile supply and demand as well as meet both current and developing needs, and ultimately to avoid the threat of a looming digitization divide.

4.3. Research Implications

The research provided a framework, i.e. a theoretical model, and translated it into a toolkit to assist healthcare organizations in the execution of data warehousing evaluation. Assessment dimensions, components and factors have been defined. The operationalization of the factors has been introduced along with a scoring structure and the assignment of evaluation methods. It is now necessary to investigate the model/toolkit's application on a wide enough scale to acquire meaningful feedback on its impact. This would make available additional knowledge on the delineation between the assessment of the system itself and of the results obtained at the project level. More importantly, it would provide a basis for sound and objective benchmarking, from a technological standpoint but also in terms of healthcare efficiency improvements, by assessing such efficiencies and how they are obtained against commonly shared standards.

The research implications extend beyond data warehousing. Evaluation models and toolkits should be tailored to other major healthcare information systems. This would result in an overall evaluation portfolio which would increase return on investments at the organization level while providing factual evidence for the analysis of the progress made towards healthcare reform.

More than research per se, evaluation should be carried out not only within healthcare organizations and the industry but with the systematic inclusion in teaching institutions' curriculum of comprehensive courses on health information systems' evaluation. Out of the top 150 health informatics programs currently offered by academic institutions in the US, only 28 include courses on health information systems evaluation.

4.4. Need for Result-Oriented Cooperation between Actors

Paradoxically, in an era characterized by the ability to share massive amounts of information in record time, effective and result-oriented cooperation between actors remains challenging. Rather than the purposeful blending of strengths, isolated approaches continue to prevail and with them the yielding of counterproductive results. While the production of systems lacking effectiveness persists, some of healthcare organizations' key needs remain unaddressed and a wealth of knowledge remains locked in academic environments.

Far from being an idealistic aspiration, result-oriented cooperation is the only effective way of enabling methods such as benchmarking, the dissemination of best practices and the adoption of standards. The improvement of healthcare efficiency is by definition an area that calls for multidisciplinary initiatives involving the coordinated contribution from areas ranging from health policy to information science.

With regard to health data warehousing, the Healthcare Data Warehousing Association has facilitated the exchange and communication between actors in the healthcare industry for over a decade. Its membership base is unparalleled, both in terms of expertise and experience, and includes academic centers. The association has proved an invaluable platform for the empirical study and constitutes an ideal research environment. It is uniquely positioned to set the agenda of and host result-oriented cooperation to coordinate the definition, adoption and assessment of standards by and for healthcare organizations, the data warehousing industry and academic centers.

Conclusion

Through an empirical study based on semi-structured interviews, the research provided an overview of the state of health data warehousing evaluation and the use of the system to improve healthcare efficiency. The research also involved the design and partial testing of an evaluation model and its practical counterpart, a toolkit intended for use by healthcare organizations. Since such investigation and assessment tools had not yet been conducted and introduced, the research bridged a key information gap.

Those organizations which have been able to leverage data warehousing to significantly improve healthcare have done so at the expense of lengthy and painstaking efforts. Bringing sustainability to healthcare systems is an urgent issue throwing actors into a race against time. Alleviating the time pressure while avoiding reinventing the wheel are of the essence and require frameworks to enable advances in analytics, process improvement and patient care standardization to be readily compared, understood and broadly adopted. The research contributes to this vital improvement by offering a basis for benchmarking in one area, i.e. data warehousing, while giving actors the means to improve their use of the technology.

The integration of a plurality of factors had been identified as one of the areas in need of further development in order to advance information systems evaluation research. The empirical study supports this advancement by providing a model/toolkit that effectively produces integration from five different perspectives:

Plurality of users.

Health data warehousing is destined for use by decision makers in all areas of healthcare, from clinical to financial, operational and research, and therefore serves a broad range of users with varied backgrounds and areas of expertise. The assessment of the technology therefore offers the opportunity to take this plurality of users into account while addressing the direct impact on the care provided.

Plurality of systems.

Since data warehousing is made up of and depends on various applications, its evaluation is by definition multi-system.

Plurality of phases.

From design to implementation, health data warehousing requires a considerable amount of time and the use of the technology serves a long-term perspective. Consequently, its evaluation cannot be limited to a single point in time and offers the opportunity to conduct the assessment within a broader timeframe and by taking a plurality of phases into account.

Plurality of findings.

Assessments are the prerequisite to understanding the causes of negative outcomes and to the improvement of unsatisfactory results. The transparent reporting of such assessments offers a practical demonstration of the benefits of integrating a plurality of findings.

Plurality of methods.

If quantification is at the core of sound evaluation, the understanding of factors such as roles, norms and values cannot be reduced to quantitative measures. The multiple dimensions and components of health data warehousing evaluation illustrate the need for and justification of the simultaneous use of various methodologies.

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