

Framework of Performance Measures for Health Information Exchange (HIE)

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Abstract

Health Information Exchange (HIE) is the most prevalent patient information sharing technology currently in use. Although a number of regional healthcare information systems exist in Japan, little is known about the effectiveness of the systems or how effectiveness should be measured. As an approach to this issue, we developed a framework for measuring effectiveness of HIE using the dimensions for health indicators from ISO/TS 21667:2004 "Health Indicators Conceptual Framework". Three phases for measuring HIE are defined: Phase I: the static aspects of a system; Phase II: the use of the system; Phase III: the outcomes of the use of the system. Complex factors involved in HIE are organized and objectives of evaluation are made clear. The domains to which measures are applied and categories of measures are defined. Sample measures extracted from publications and co-authors' studies are discussed. This work is the first step towards the systematic development of a framework of measures of the effectiveness of HIE.

Keywords:

Health Information Exchange, Quality Indicators, Cost Effectiveness, Information Systems

Introduction

It is expected that health information technology can facilitate information sharing regionally, nationally, and internationally to facilitate continuity and quality of care. In recent years, the term "HIE (Health Information Exchange)" has become the most widely used term for regional healthcare information systems.

According to the web site of the US government HealthIT.gov, HIE is defined as follows:

HIE generally refers to sharing of clinical data between health care institutions for efficiency, cost-effectiveness, quality care, and for patient safety.

A number of regional healthcare information systems exist in Japan, where hospitals, clinics and pharmacies share patient information electronically. According to a working paper published by Japan Medical Association Research Institute in 2015, more than 200 systems exist in Japan [1].

Systematic reviews and a number of original papers that focus on effectiveness of HIE discuss major concerns about regional healthcare information systems' effectiveness [2-8]. Even though a huge amount of money has been expended, systematic effectiveness analyses of these systems has seldom been conducted.

Effectiveness of a healthcare information systems is difficult to evaluate because multiple factors are involved including human (personnel), organization, workflow/process, as discussed by Sittig and Singh in their paper "A New Socio-technical Model

for Studying Health Information Technology in Complex Adaptive Healthcare Systems" [9].

To systemically assess the effectiveness of regional healthcare information systems, we investigated what and how measures were obtained, what measures are feasible, how the various factors may be captured and organized, and how efficiency and effectiveness can be evaluated.

Our study focuses on effectiveness of regional healthcare information systems where patient information is shared between hospitals, clinics and pharmacies. Since the objectives and the concepts of the systems are represented by HIE, we will use the term HIE and regional healthcare information systems interchangeably.

As a result of our study, we have developed a framework for measures of HIE. We present the major results and discuss issues that should be addressed.

Methods

The methods and the process for the Framework development are shown below (Figure 1).

1. International Standards and Technical Reports on health systems performance indicators that discuss both qualitative and quantitative aspects were examined [10], and the dimensions for measures of HIE were derived.
2. Domains to be measured and categories of measures were defined based on published papers on HIE [2-8].
3. The domains to be measured and categories of measures are reviewed in the light of the Donabedian model that provides a framework for examining health services and evaluating quality of healthcare.
4. A survey on regional healthcare institutions and users (clinicians) in Japan were conducted and the results were reflected in the framework. Some measures were investigated for feasibility and usefulness.
5. Co-authors conducted several studies on some measures experimentally, and the results were reflected in the framework. Quality indicators adopted in the co-authors' institutions were also investigated.

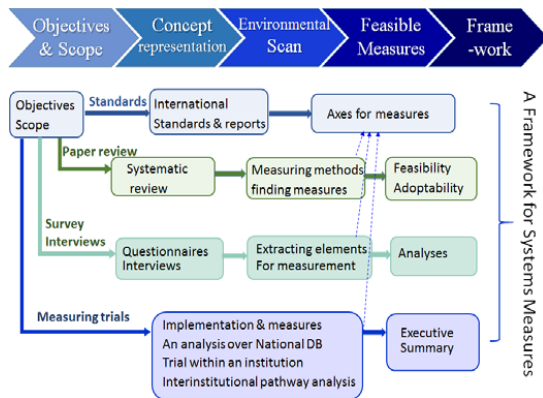


Figure 1 - Framework development: the methods and process

Results

Conceptual Representation of Healthcare and HIT

When improvements in continuity of care are observed after adoption of hospital information systems (HISs), it may be due to changes in human attitudes, workflow, care process, etc. Sit-tig and Singh presented a model with eight dimensions in their article “Socio-technical Model for Studying Health Information Technology in Complex Adaptive Healthcare Systems,” stating that HIT interventions must be understood in the context of their simultaneous effects across multiple dimensions of the model [9].

We present a conceptual representation of healthcare and HIT in Figure 2. The areas in orange show healthcare itself regardless of existence of HIT. Concepts such as “quality healthcare”, “quality measures”, “patient engagement” exist regardless of HIT. The areas in blue are components of HIT such as EHR or “data interoperability.” The overlaps between the concepts in orange and blue areas are apparent. HIT is not a simple combination of healthcare and IT. It is a new healthcare domain established with the advent of Health Informatics.

Effectiveness Measures - Literature Review

We have investigated papers on effectiveness of HIE. There are a number of original papers and several reviews including, “Outcomes from Health Information Exchange: Systematic Review and Future Research Needs” by Hersh, et al [3]. It is an in-depth review discussing the limitations of the studies under review. In their review, 34 studies on outcomes of HIE were identified. Most of the papers on HIE effectiveness focused on healthcare resources. Some papers discussed a decrease in laboratory testing and amount of costs. For hospital admissions, some show a decrease in the number of admissions, but others show no decrease. HIE in general reduces duplicative laboratory and radiology testing, emergency department costs, and hospital admissions. There are also reports on public health reporting and ambulatory quality of care. But papers on the effects of HIE on clinical outcomes have not been found.

Framework of Effectiveness Measures of HIE

Eight Dimensions of Measures

International organizations such as ISO and OECD published frameworks for health quality or health systems performance. For example, “ISO/TS 21667:2004 Health informatics - Health Indicators Conceptual Framework” shows performance indicators for health systems with eight dimensions below [10]:

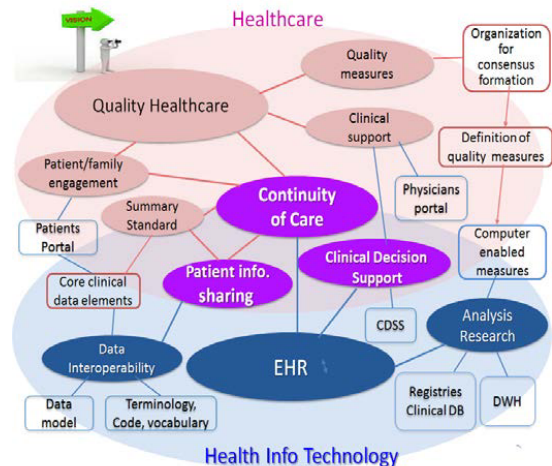


Figure 2 - Healthcare and Health Information Technology

- **Acceptability:** All care/services provided meets the expectations of the client, community, providers and paying organizations, recognizing that there may be conflicting, competing interests between stakeholders, and that the needs of the clients/patients are paramount.
- **Accessibility:** The ability of clients/patients to obtain care/service at the right place and the right time, based on respective needs.
- **Appropriateness:** Care/service provided is relevant to the clients'/patients' needs and based on established standards.
- **Continuity:** The ability to provide uninterrupted coordinated care/service across programmes, practitioners, organizations, and levels of care/service over time.
- **Competence:** An individual's knowledge and skills are appropriate to the care/service being provided.
- **Effectiveness:** The care/service, intervention or action achieves the desired results.
- **Efficiency:** Achieving the desired results with the most cost-effective use of resources.
- **Safety:** Potential risks of an intervention or the environment are avoided or minimized

The eight dimensions of performance indicators are for health system performance. We applied the eight dimensions above to health information systems or HIE in our framework, using the term “measures” instead of “indicators”.

Effectiveness Measures – Three Phases

Various aspects are involved in evaluating HIE, including organizations, personnel, operations, system functionality, system use rate, patient participation, provider satisfaction, and patient outcomes. Taking these into account, we arranged performance measures of HIE in the three phases (Figure 3):

Phase I: System organization (including both IT and human)

Phase II: Use of HIE

Phase III: Effects by the use of HIE

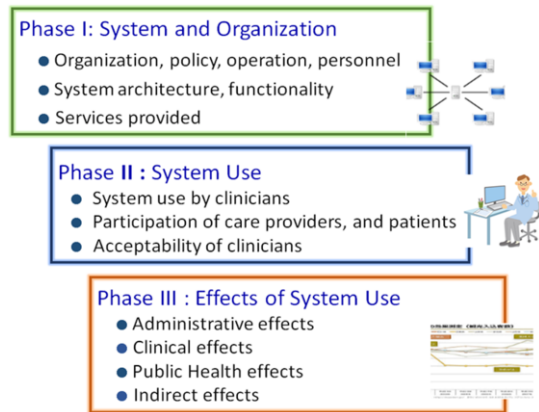


Figure 3 - Measuring HIE: Three Phases

It does not necessarily mean that the HIE should be measured in this order. Phase I may include such domains to be measured as organization, policy, operation, system functionality and services provided. Phase II includes domains such as use by clinicians, participation of patients, acceptability by healthcare providers, and patient satisfaction. Phase III includes domains such as administrative effects and clinical effects. There may also be public health effects, and indirect effects

such as conformance rate of clinical guidelines.

We investigated how measures may be captured from the view point of Donabedian's "Structure, Process, and Outcome" [11]. We considered HIE not only as an information technological system, but also as a socio-technological system that includes organizations, personnel, operation and so on. From this point

of view, we considered the Phase I "Structure", and Phase II "Process." Phase III was considered "Outcome." For Phase III, we represented outcomes if they measure aspects resulting (directly or indirectly) from the use of the system. Hence the measures in Phase III may be classified as "Process" rather than "Outcome" from the view point of clinical quality measures.

Overview of the Framework

Figure 4 shows the overview of the developed framework for HIE effectiveness measures. Shown in the columns are eight dimensions for performance: "Acceptability, Accessibility, Appropriateness, Competence, Effectiveness, Efficiency, Safety, and Continuity." In the rows, the major domains are organized into the three phases. Then in each domain, categories of measures are shown.

Example measures

The framework does not include concrete measures, but some measures are shown as examples in Figure 5. Measures for Phase I and Phase II are mostly straightforward. Some of them are taken from our survey carried out in 2014 in Japan across five regional healthcare information systems. For a given measure, the relevant dimensions are shown by a check mark. A large thick check mark indicates strong relevance, while a smaller check mark indicates weak relevance. For example, for "the number of years in operation" in the domain "information system organization," a large check mark is shown under the column "Continuity."

Most of the sample measures in Phase III were found in the literature. We reviewed the papers and extracted measures that are generally considered feasible. Papers on HIE effectiveness mostly focus on healthcare resources. For example, "amount of reduced testing/imaging" in the domain "Laboratory & other tests" is found frequently in literature review, and is most relevant to the "Efficiency" dimension and also relevant to "Appropriateness", "Continuity" and "Safety".

Phases of Measuring HIE	Measured Domains	Category of Measures	Example Measures	Acceptability	Accessibility	Appropriateness	Competence	Continuity	Effectiveness	Efficiency	Safety
Phase I	System Organization	Information system organization									
		Management/Staff organization									
		Operation policy									
System construct Organization Policy	System Functionality, Services	User interface									
		Support for patient engagement									
		Data interoperability									
Phase II	System use	Support for secondary use									
		Services to care providers									
		Institution participation									
Phase III	Effects of System Use	Patient participation									
		Use by care givers									
		Care givers satisfaction									
Phase III	Effects of System Use	Cost per participation									
		Laboratory & other tests									
		Admission									
Phase III	Effects of System Use	Emergency department visit									
		Drug administration									
		Preventive medicine									
Phase III	Effects of System Use	Quality measures for a given disease									
		Information sharing among relevant institutions									
		Clinical guideline compliance rate									

Figure 4 - Overview of the developed Framework of Measures for HIE

Some measures are from the co-authors' work or used in their institutions. For example, "improvement of HbA1c (Surrogate)" and "cancer survival rate (True)" are measures for the domain "quality measures for a given disease," and a check mark is shown in the "Effectiveness" column. Measures such as "rate of BP lower than 140/90" is one of compliance rates of a clinical guideline under the domain "Other/indirect effects."

measures are mostly descriptive statistics, and although there may be discussions about what measures should be adopted, measuring should not be difficult. Many of the sample measures shown are taken from our survey on five regional healthcare information systems. For example, "How much would you spend for the system you participate in?" was a question for clinicians; we found the median acceptable cost was almost equal among five systems.

In the past, there were no clear guidelines for measures, and the

Domains	Category of Measures	Example Measures	Acceptability	Accessibility	Appropriateness	Competence	Continuity	Effectiveness	Efficiency	Safety
System Organization	Information system organization	number of years in operation initial/maintenance costs					✓		✓	
	Governance/Staff	staff (engineers, administrative, etc.)			✓					
	Operation policy	business continuity planning patient consents(including withdrawal)			✓					
					✓					
System Functionality, Services	Support for patient	information provided to patients			✓					
	Data interoperability	sharable (exchangeable) information standards adopted (terminology, code) bidirectional exchange				✓				
						✓				
						✓				
	Data storage and usability	disaster countermeasures usability for research					✓			✓
Use of System	Services to clinicians	clinical measures provided to clinicians				✓			✓	
	Institution participation	rate of participating clinical institutions (hospitals, clinics, pharmacies)			✓					
	Patient participation	rate of registered patients patient satisfaction	✓	✓						
			✓							
	Use by care givers	rate of care givers using the system frequency of the use of the system	✓	✓						
			✓	✓						
Administrative, Clinical effects	Care givers satisfaction	how much is worth spending	✓						✓	
	Cost per participation	cost per size of the system							✓	
	Laboratory & other tests	amount of reduced testing/imaging cost savings due to reduced testing			✓		✓		✓	✓
	Admission	reducing hospital admissions lower costs for (re)admissions							✓	
									✓	
	Emergency dept. visit	reducing emergency dept. revisits				✓				
	Drug administration	decrease in duplicated of medication decrease in inadequate prescription by medication reconciliation					✓	✓	✓	✓
Public Health effects	Preventive medicine	increase in vaccination rate, e.g. pneumococcal vaccination			✓		✓			
	Quality measures for a given disease	improvement of HbA1c (Surrogate) cancer survival rate(True)						✓		
								✓		
	Information sharing among relevant institutions	improved completeness of reporting for notifiable diseases improved identification of HIV patients for follow-up care			✓	✓				
		clinical guidelines compliance rate,e.g.,								
	Other/indirect effects	rate of HbA1c<7.0% rage of BP lower than 140/90						✓		
								✓		

Figure 5 - Framework of Measures for HIE with sample measures

Discussion

Implementation of HIE measures of Phase I and Phase II

The term and the concept of HIE is in use more and more in the field of Health Informatics. HIE mostly refers to the electronic information sharing among clinical institutions, for efficiency, cost-effectiveness, quality care and safety.

In the framework presented, three phases are defined for measuring the effectiveness of HIE. For Phase I and Phase II,

framework should serve as a sharable tool for governance of the regional healthcare information systems.

Implementation of HIE measures of Phase III

For measures of the third phase, i.e., measures for outcomes, further discussion may be necessary. Among a number of published papers, the systematic review by Hersh et al, which outlines the need for more research, aligns closely with our current work. They discussed the significant limitations of the evidence base, and showed four primary limitations of the available evidence on the impact of HIE (and Health IT in general). That is,

(1) suitability of study design; (2) execution of the studies; (3) complexity of the interventions with implications for interpretation and for generalizability; and (4) changes in the technology or policy governing its use. The evidence level of the studies investigated was considered low to moderate due to multiple limitations [3].

A primary limitation is due to the complexity of interventions. The HIE itself is necessarily only part of a more complex intervention, and the mixed effects might change the behavior of clinicians or others in the health systems. For example, if HIE effect on the compliance rate of electronic clinical guidelines is measured, multiple interventions (factors) are involved. When some sample measures are applied in clinical settings that employ a HIE, possible factors involved other than HIE may need to be considered when reporting the results.

Framework as an approach to Health IT evaluation

The US Agency for Healthcare Research and Quality published the report "Identification and Prioritization of Health IT Patient Safety Measures, Final Report" [12], which discusses that while the use of Health Information Technology (HIT) presents many new opportunities to improve patient care and safety, the complex interactions between people, processes, culture, and technology can also create an environment where new hazards are introduced. There is a need for measures to help identify the nature, scope, and prevalence of HIT-related safety issues and to assess how well providers, vendors, and others are preventing and/or mitigating HIT-related safety concerns.

Similar discussions apply to the third phase of measures of the framework developed in the present study. The concepts and sample measures for "Outcome" serve as the groundwork for the complex discussions of effectiveness of regional healthcare information systems.

Conclusion

Healthcare information systems and HIT are widely viewed as essential to the transformation of healthcare to counteract rising costs, inefficiency, preventable errors, and quality of care. HIT is expected to yield benefits in quality, safety, and efficiency of healthcare. The Japanese government as well as the US and other countries' governments have been engaged in a concerted effort to promote adoption of HIT. Despite the considerable investment and the widespread rapid adoption of HIT, little is known about the effectiveness or cost-effectiveness of the systems, that is, how useful the systems are.

As an approach to this issue, we developed a framework for measuring the effectiveness of HIE. The framework comprises of three phases of measures and eight dimensions of quality. It is recommended that responsible organizations measure their systems for monitoring and for governance at Phase I and II. For Phase III, due to complex factors involved and limitations of studies, literature reviews showed that the evidence level is relatively weak. This is generally true when an outcome measure is applied to a specific setting, and considerations may be necessary in presenting the results as the effects may be the mix of HIE and other factors.

We conclude that the framework will assist administrators, healthcare providers, researchers and regional communities as a tool to measure the effectiveness of regional healthcare information systems, thereby contributing to the evaluation and improvement of their systems, and ultimately improve quality care.

Acknowledgements

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