Strong and Meaningful Use of Healthcare Information Systems (HIS)

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Abstract: The translation of science to practice to policy for meaningful use of healthcare information system (HIS) is embedded in a complex milieu of meaningful, meaningless, non-, and mis- use of the system by a variety of stakeholders seeking to manage the cost, quality, safety, and parity of healthcare. The problem of HIS use can be modeled as an ontology which encapsulates the core logic of use. The ontology includes the three components of translation, the four types of use, the key stakeholders, and the four basic outcomes. It is a comprehensive structured natural-language model which can be extended and refined. It is parsimonious and can be easily understood and interpreted by all the stakeholders. We argue that such a model is necessary to develop a roadmap for strengthening the meaningful use of HIS. In its absence meaningful use of HIS will be weak.

1 INTRODUCTION

A strong science is a foundation for effective practice; a deep knowledge of practice is a foundation for effective policies; and an ongoing assessment of the outcomes of the practices and policies provides feedback to redirect the science, practice, and policies. We draw upon Platt's (Platt, 1964) concept of 'strong inference' to articulate the concept of strong science, practice, and policy as disciplines which will help clearly resolve equivocalities at each stage of translation. For the continuous translation of science to practice to policy and the feedback to be effective, the translation/feedback focus has to be symmetrical.

The dysfunctions of asymmetric focus in healthcare are evident from history. It took a long time for the US health system to emphasize the prevention of illnesses as much as it did their cure, increasing the cost of healthcare. A recent study highlighted the cost of the focus on breast cancer cure to the exclusion of its prevention from consideration (Interagency Breast Cancer and Environmental Research Coordinating Committee, 2013). Similarly, while there are many studies of health disparities, there are very few of health parities, disease parities, and disease disparities. In PubMed literature between 2002 and 2012, the dominant – almost exclusive – focus is on health disparities (Ramaprasad and Thirumalai, 2012). Last, while there is voluminous literature on eliminating obesity there is very little on increasing the opposite of obesity, for which there isn't even a formal word – even the language comes in the way. Should the opposite of obesity be called normalcy, un-obesity, non-obesity, or nobesity?

As healthcare information systems (HIS) have become central to the delivery of healthcare, the science, practice, and policy of their use have become an important concern. The science of use of HIS is focused on the technical design of the systems, human-computer interactions, and the cognitive, behavioral, and social aspects of its use. The practice of use of HIS is focused on the implementation of the systems, managing the change, and the outcomes of the change. The policies of the use of HIS are focused on guidelines at the different levels of healthcare institutions (clinics, hospitals, etc.), governments (local, state, federal, etc.), and other stakeholders about their use. Ideally the science, practice, and policy have to be aligned – the challenge is to do so.

While in the US a staged plan to encourage their use, with incentives, goals, and measures has been introduced, the issue is of concern in other countries too. This paper plays off the phrase 'meaningful use' coined in the US for the purpose. The staged incentive program has spawned a considerable

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amount of literature on the science, practice, and policy of meaningful use. We argue that such a focus is asymmetric and hence will be ineffective. While the phrase may correctly describe the desired state of the use of HIS, to achieve it one has to study the use in the context of other possible states, namely: meaningless use, non-use, and mis-use.

For example, consider the implementation of drug-drug and drug-allergy interaction checks. These checks will directly affect the quality and safety (Crosson et al., 2012, Rahmner et al., 2012, Spina et al., 2011) outcomes of healthcare (Classen et al., 2011). Their effectiveness will depend upon the providers' response to the alerts issued based on the checks. Recent assessment shows that more than 90% of the alerts are overridden due to alert fatigue (Smithburger et al., 2011, Phansalkar et al., 2012b, Crosson et al., 2012), information overload (Callen et al., 2011), poor user interface Design (Seidling et al., 2011, Gaikwad et al., 2007, Rahmner et al., 2012), poor specification of the critical interactions (Gaikwad et al., 2007), and inadequate analysis (Phansalkar et al., 2012a, Takarabe et al., 2011) of the interactions.

Thus the alternatives to meaningful use are not just a semantic play on words but realities in the context of many information systems, including HIS. A user going through the motions of using a system, just for appearance, while not really integrating it into his or her decision making processes would be an example of meaningless use. Idle information systems and functionalities are a common occurrence indicating non-use. Worse, use of the system for fraud would be misuse – an important concern given the escalation in healthcare fraud. Instead of considering any use other than meaningful use as being simply aberrant, it would be appropriate to consider them as part of the use continuum.

The dynamics of meaningful use are not necessarily the opposite of that of meaningless use; the dynamics of non-use are not simply the opposite of use. An asymmetrical science of meaningful use of HIS will result not only in a weak science but also in weak practices and policies too. A symmetrical approach to HIS use is needed. We argue that meaningful use of HIS has to be studied explicitly in conjunction with meaningless use, non-use, and mis-use of these systems to develop (a) a strong science of use of HIS, and (b) translate the science into strong practices and policies for use of HIS.

All the four types of use coexist in any HIS, in different proportions. Expert stakeholders may use it meaningfully; novice stakeholders may use it meaninglessly or not use it; and fraudsters may misuse it. Incentivized stakeholders may use it meaninglessly, enough to obtain the incentives; non-incentivized stakeholders may not use it at all. How

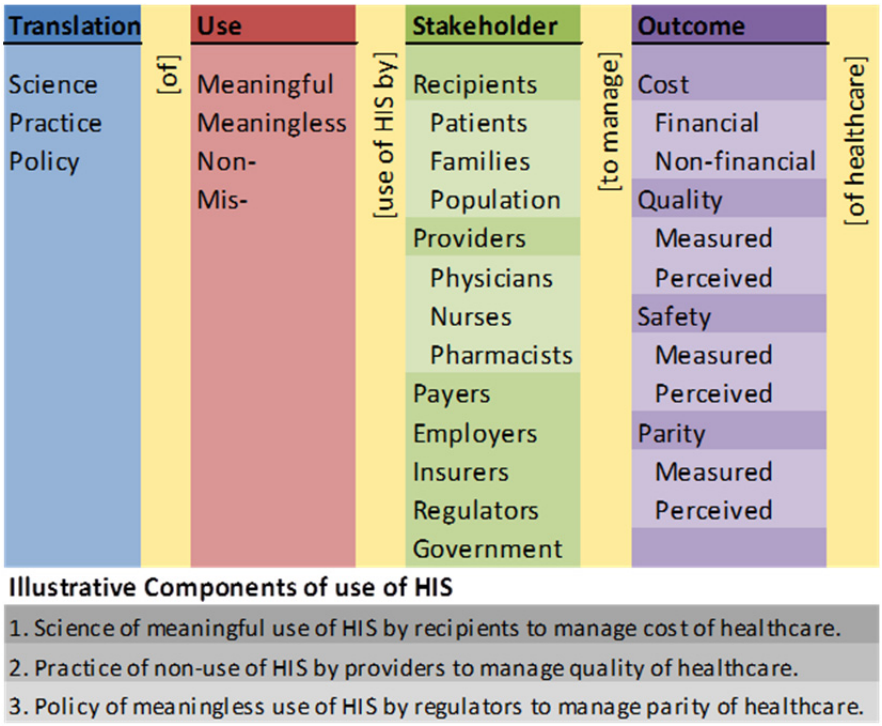

Figure 1: Ontology of Use of Healthcare Information Systems.

much the stakeholders, as a whole, use it meaningfully, meaninglessly, not at all, or misuse it will determine the impact of HIS on cost, quality, safety, and parity of healthcare – the four outcomes sought from the meaningful use programs. It would be foolhardy to expect that the HIS will be used meaningfully to the complete exclusion of non-use and meaningless use. The combinations of translation (Science, Practice, and Policy), use, stakeholders, and outcomes of HIS use have to be addressed systemically, systematically, and symmetrically to transform healthcare.

The use of HIS in healthcare described above is complex problem. Its complexity has to be deconstructed. Its core logic and all the components can be conceptualized using the ontology shown in Figure 1. It is a structured natural language model of the problem. It can be used to analyze the extant literature and develop a roadmap for the science, practice, and policy of HIS. We will discuss the construction of the ontology and application to developing the roadmap.

2 ONTOLOGY OF USE OF HIS

We have conceptualized the ontology of use of HIS along four dimensions, namely: (a) Translation, (b) Use, (c) Stakeholder, and (d) Outcome. In the following we will discuss each dimension.

There is nothing sacrosanct about these four dimensions – it is simply the lens through which we have chosen to study the problem. They are parsimonious and fundamental for the task at hand. One could conceivably add a spatial dimension to study geographical differences or add a temporal dimension to study the evolution of meaningful use. These dimensions can be added in subsequent analysis too, if necessary, because the ontology is extensible.

2.1 Translation

Science, Practice, and Policy are separate knowledge domains yet tightly connected. The Translation dimension encapsulates the continuous process of translation of (a) science to practice, and (b) practice to policy. It also encapsulates the continuous feedback (a) from practice to science, and (b) from policy to practice and then to science.

The Translation dimension is shown as an ordinal taxonomy of the three elements in Figure 1 – it presumes the commonly used order of translation from Science to Practice to Policy. The order may be changed to reflect a different point of view. Or, they could be simply considered to be nominal. Should one modify the translation process by adding another step or refining an existing one, the modification can be encoded in the dimension as an additional category or subcategory. For example, Assessment may be added as a fourth element of Translation, or Science may be subcategorized into Basic and Applied sciences.

The translation and feedback processes are neither natural nor automatic. In the absence of these continuous links, the three will tend to become disconnected and ineffective. There are significant incentives for disconnection and disincentives for integration. The different disciplinary homes for the three domains are an incentive for disconnection. The lack of support for interdisciplinary work is a disincentive for integration. The lack of seriousness about assessment and learning is both an incentive for disconnection and disincentive for integration. Findings from the emerging discipline of translational science should help, in the long run. However, the new science is primarily focused on translation of biomedical research and not HIS.

2.2 Use

Meaningful use has been very salient in the literature, especially due to the incentive program instituted by CMS (Blumenthal, 2009). It is a good phrase; it is desirable; but, an exclusive focus on it is dysfunctional. Meaningless use, which can be construed as the opposite of meaningful use, has been suggested in criticisms of HIS but has not been a significant object of study, as for example in the context of alert overrides discussed earlier. One underlying assumption may be that the two are mutually exclusive complementary categories, as a consequence of which the presence of one is seen as an indicator of the absence of the other. Thus increase in one would result in a decrease of the other – a zero-sum situation. However, the complementary assumption would be incorrect if the two are concurrent categories, both coexisting simultaneously. The zero-sum assumption would not hold. Both meaningful and meaningless use could vary independently. We believe the two are concurrent.

Similarly, non-use is often seen as an indicator of the failure or ineffectiveness of an HIS, but not as an explicit object of study. It should be considered as such in the use spectrum. It may be a sign of poor design, over design – too many functions without much use, poor training, or simply ignorance. It

includes aspects of the HIS which could be used to improve the outcomes and aren't. Non-use too can coexist with meaningful and meaningless use.

Last, but not the least (a cliché, but very appropriate here), while there is a lot of attention given to healthcare fraud using HIS such as upcoding, illegal billing, etc. they have not been grouped together as mis-use of HIS. There are lesser forms of misuse too which can affect outcomes such as cutting and pasting medical notes propagating past errors, careless checking of boxes, etc.

The Use dimension in the ontology conceptualizes the four types of use as part of a continuum. They are independent and can coexist – one is not defined as a negation or by the absence of another. The categories are can be considered to be complete. If necessary, the dimension can be modified by adding categories or refining existing ones with subcategories.

2.3 Stakeholder

The stakeholders are the users of the HIS. The seven broad categories of stakeholders in the ontology are the Recipients of, the Providers of, the Payers for, the Employers (of recipients) of, the Insurers of, the Regulators of healthcare, and the Government. The recipients of healthcare may be individual Patients, patient Families, or a Population. These are shown as subcategories of Recipients in the ontology. Similarly, the subcategories of Providers are Physicians, Nurses, and Pharmacists. The Stakeholder dimension can be extended by adding more categories, reduced by eliminating categories, refined by adding subcategories, coarsened by combining categories or subcategories. Through these operations the use of HIS can be studied at different levels of granularity. The categories, as shown, are nominal – they may be reordered without loss of information. They may also be ordered based on, for example, their importance or sequence in the process of healthcare delivery.

The use of HIS by stakeholders can vary significantly and so could their desired outcomes. While the Payer may consider the use of HIS for managing costs of healthcare as being Meaningful, the Provider may see it as Mis-use. The variations in the perceptions of the different types of Use and the priorities of the different Outcomes have to be part of the Science, Practice, and Policy of use of HIS.

There is a considerable amount of interaction between the stakeholders using the HIS and also because of it. The Providers and the Recipients may see the lab results simultaneously using the HIS, which may lead to better care. On the other hand an insurer may mine the data on a Provider's care history and question his or her practices, resulting in conflict and tension. These interactions can be mapped by crossing the categories of Stakeholders in a two-dimensional table, and have to be considered in the development of the Science, Practice, and Policy. Higher order dimensions are more complex. They exist and can be mapped with higher order tables. The taxonomy of stakeholders can be used to develop a cognitive map of the interaction among them. It must be noted that the interactions can be two-way and not just one-way, and multi-way in the case of higher order interactions. The identification and recognition of this symmetry will be central to the development of a strong science, practice, and policy of use off HIS.

2.4 Outcome

Cost, Quality, Safety, and Parity of healthcare are the four outcomes specified in the CMS Stages 1 and 2 criteria (Centers for Medicare & Medicaid Services). They are more or less universal. We have subcategorized Cost as Financial and Non-financial, and the other three as Measured and Perceived. The dichotomous distinctions are important – their information bases are different and they are not perfectly correlated. Perceived quality, for example, may be at variance with measured quality.

The order of the outcomes listing reflects the general emphasis in the CMS criteria; however, the order may vary by stakeholder or be changed. As with other dimensions the granularity of Outcomes can be changed by varying the categories and subcategories.

There can be a considerable amount of interaction between the outcomes. For example, improvements in Quality may affect the Cost; improvements in Safety may decrease the Cost; and improvements in Quality may improve Safety. These and higher order interactions too can be mapped by crossing the Outcome categories in a two-or higher-dimensional table. As with stakeholders the taxonomy of outcomes can be used to develop a cognitive map of the interactions among them. And these interactions too can be one-way, two-way, or multi-way.

3 COMPONENTS OF USE OF HIS

The components of use of HIS can be enumerated by concatenating natural English sentences from the

four dimensions (columns) and the interleaved words/phrases between the columns as illustrated at the bottom of Figure 1. They are:

1. Science of meaningful use of HIS by recipients to manage cost of healthcare. For example, use of the internet by patients and their families to compare the cost of surgery in different facilities.

2. Practice of non-use of HIS by providers to manage quality of healthcare. For example, override of drug-drug interaction alerts by physicians.
3. Policy of meaningless use of HIS by regulators to manage parity of healthcare. For example, use of poor public health data on parity of healthcare for regulating diet in school meals.

The ontology encapsulates 336 (3*4*7*4) first-level components and 1,056 (3*4*11*8) second-level components of use of HIS. The ontology provides a convenient way of studying them without enumerating them – the latter would run into many pages.

Looked at differently, the ontology is a complete, closed description of the problem of use of HIS. It is a visualization of the problem space of science, practice, and policy of HIS. We underscore the indefinite article 'a' to indicate the possibility of other formulations as well as refinements and extensions of the present formulation. New dimensions can be added or current dimensions reduced. New categories and subcategories can be added or current ones collapsed or removed. By manipulating the ontology in these ways one can obtain different perspectives on the problem at different levels of granularity.

It must be noted that addition/reduction of dimensions/categories changes the number of components combinatorially. Thus, the additions can dramatically increase the complexity at the cost of parsimony. The two opposing forces have to be balanced for an effective study of the science, practice, and policy of the use of HIS. Our objective is to make parts of the problem and the whole problem visible parsimoniously – on less than a single page.

Ideally, a systematic, systemic, and symmetric study of the science, practice, and policy of use of HIS should consider all the components. Some of the components may be instantiated as in the illustrations above. When they are instantiated frequently we can call them the 'bright' spots; when instantiated infrequently we can call them the 'light' spots. There are likely many 'bright' spots regarding meaningful use and 'light' spots regarding non-use. Some components may not be instantiated at all. The absence of instantiation may be because the component has been overlooked or it is infeasible. We will call the overlooked components the 'blind' spots, and the infeasible components the 'blank' spots. It is difficult to determine *a priori* whether an absent component is a 'blind' or a 'blank' spot. There are likely many 'blind/blank' spots regarding meaningless use.

The extant literature – scientific, practice, and policy – on the use of HIS can be exhaustively mapped to the ontology using qualitative analysis tools like consensus coding and NVivo. Some articles may cover multiple components of the ontology, some multiple snippets (parts of a component), and some may cover a few components or snippets. Some articles may not map to the ontology at all which may suggest the need to modify the ontology to accommodate overlooked elements of the problem.

Such a mapping will highlight the 'bright', 'light', and 'blind/blank' spots in the science, practice, and policy of use of HIS. These maps can be analyzed to determine the gaps (a) within the science, practice, and policy, and (b) between the science, practice, and policy of use of HIS. The former are discipline gaps and the latter translation gaps. An analysis of the antecedents and consequences of these gaps will help develop a roadmap for science, practice, and policy for HIS.

In the conclusion we will describe how mapping the 'bright', 'light', and 'blind/blank' spots in the literature using the ontology can be used to develop a roadmap for science, practice, and policy of HIS.

4 CONCLUSION: ROADMAP FOR STRONG AND MEANIGFUL USE OF HIS

The roadmap for a strong science, practice, and policy of HIS cannot be asymmetric – it cannot have only left turns or right turns; it cannot focus only on meaningful use and not consider meaningless, non-, and mis-use. One way to improve the roadmap is to bridge the gaps between the ideal (as portrayed by the ontology) and the real (as portrayed by the bright, light, blind/blank spots).

A 'bright' spot in a domain may be the consequence of the priority set by the funding agency or the gatekeepers of the domain. On the other hand, it could also be the consequence of a 'herd' effect – it is easier to obtain grants and

publish 'more of the same'. If the former, the brightness of the spot may be functional and the emphasis should be maintained; if the latter, it may be dysfunctional and emphasis should be changed. A 'light' spot may indicate its lack of importance or that it is an emergent focus. Last, a 'blank' spot may be unimportant or important but overlooked. If unimportant it may need to be so; if important the emphasis needs to be changed.

A 'bright' spot in science and a corresponding 'blank/blind' spot in practice may indicate the need for translation or the practical irrelevance of the research. By the same token, a 'blank/blind' spot in science and a corresponding 'bright' spot in practice may indicate misplaced practice or a practice which needs to be researched.

Thus through an analysis of the antecedents and consequences of the gaps within the domains of science, practice, and policy and between them using the ontology one can construct a better roadmap for use of HIS. While we have focused the discussion in this paper broadly on the use of HIS, the method can be used to develop better roadmaps in specific areas of healthcare where information systems play a critical role – for example, long-term breast cancer care, care for chronic illnesses, and tele-healthcare. We believe a systematic, systemic, and symmetric approach to these problems should be the standard.

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