Creating operations research models to guide RHIO decision making

Michael Ferris, Patricia Flatley Brennan, Lisa Tang, Jenna Marquard, Stephen Robinson, Stephen Wright
University of Wisconsin-Madison

Abstract

Eight years of progress towards the creation of a national health information network has resulted in a plethora of health data exchange relationships, most commonly called regional health information organizations (RHIOs). Various network types reflect both governance decisions and practical aspects, such as the need for a variety of information sharing pathways between and among organizations. Applying systematic business planning approaches will help ensure that decisions about structure, governance, pricing and incentives lead to RHIO arrangements that meet both the RHIOs' and the participants' business goals. This paper describes the model formulation stage of an ongoing project that applies operations research methods to RHIO participation decisions.

Introduction

Recent evidence of difficulty in establishing and sustaining health data exchange arrangements, including Regional Health Information Organizations (RHIO, RHIOs), highlights the need for sound business planning to create, price and manage health data exchange relationships[i].[ii] Without such models, RHIOs are left with altruism and social values to guide their decision making. Our team has proposed applying operations research (OR) models to the pricing of RHIO participation.[iii] OR methods such as discrete event simulation offer promise in informing RHIO decision makers about critical actions and consequences, such as first-actor penalties, pricing strategies, and the likely sequence in which new members will join. Since these methods are complex, as a first step in evaluating their usefulness for modeling the behavior of potential actors in a RHIO it is necessary to collaborate with RHIO decision makers in building and evaluating simplified, basic models. This paper records the steps taken to apply one OR model to an established RHIO.

Background

Several configurations of health data exchange systems are emerging, most of which balance some centralized, federated functions (usually patient identification) and some degree of peer-to-peer or centrally mediated data sharing protocols.[iv] The Santa Barbara County Care Data Exchange (SBCCDE) employed a peer-to-peer data exchange model. MA-SHARE[4] is configured as a federation of institutions that conducts decentralized information sharing supported by a community-level master patient index. The MidSouth eHealth Alliance is organized initially with a common data store supported by a master patient index. Geissinger Health System is developing a health data exchange model among its affiliate hospitals; while the physical organization of the network may match one of the existing approaches, the fact that all institutions are part of a common governance structure alters the need for institution-institution or institution-RHIO data sharing agreements. An alternative model emerges when all major players in a community agree to use the same health IT vendor, as happened at INHS in Spokane, Washington[v] and appears to be emerging in Madison, Wisconsin, where the three major hospitals have all selected the same health IT vendor (Epic Systems, Verona, WI). Having a common technical infrastructure among key participants certainly facilitates data sharing, but in no way does the technical core obviate the need for interorganizational agreement and the information standardization processes required to insure full interoperability of data.

As they are in an experimental/emerging state, most health data exchange are supported by a mix of public and private funds, and a variable level of funders. Most RHIOs, save the Cincinnati Health Data Bridge, operate with some type of government investment. Subscription fee and transaction-based costing are two common approaches to generating income. OR models could assist in establishing pricing structures that will support sustainability.

There are two important reasons why applying formal models for planning and cost-valuation of RHIOs are needed. First, decision makers, whether RHIO organizers or commercial entities, need tools that allow exploration of the cost and consequences of RHIO structure and participation. Second, formal models could help stakeholders to determine whether the anticipated costs and benefits of RHIO participation are actually realized. Indeed, some groups provide coaching for RHIO planning activities[vi], and this coaching attends explicitly to the financing strategies needed for sustainability.

Methods and Approach

Overview

Supported by a grant from the National Library of Medicine (LM 8949) our team has engaged an existing, well-established RHIO, the Indiana Health Information Exchange (IHIE), in an OR modeling project. The goals of this phase of the modeling project are two-fold: (1) to build a sufficiently accurate representation of the health data exchange environment to support creation of analytical models and (2) to demonstrate one particular analytical model that allows exploration of the consequences of various pricing policies. Through site visits and data transfers, our team has developed an understanding of this RHIO's business process. Additionally, we have vetted with them governance group key assumptions, business process goals, and a parsimonious set of variables that capture the essential set of transactions that flow through the system.

The process of modeling is an interactive one between the domain expert (here, IHIE) and the modeling team (UW-Madison). Typically, this iterative process results in a series of increasingly complex and detailed models, coupled with a firmer understanding of the major features of the underlying problem. When carried out well, the process can be instructive to both modeler and domain expert.

It was clear from initial discussions with IHIE that business/OR models could have potential not only to determine the feasibility of certain decisions, but also to aid in the process of exploring many alternative growth strategies. We followed the steps below, which we believe should be appropriate for many other modeling projects.

Step 1: Establish conduit to domain expertise
Based on a naïve understanding of the problem domain, we built a small collection of "teaser" models to showcase the potential use of operations research in the application domain.[iii] The models were simplistic, but served to highlight the mechanisms by which modeling can aid decision making. Armed with these models, we were able to approach IHIE, a key player in the problem domain, and establish a working relationship that furnished more understanding of the business goals and practices of this RHIO. This conduit facilitates the discussions, validation and refinements that form the key elements of the following modeling process.

Step 2: Model scoping visit

An initial visit to IHIE began the process of cooperation between OR experts familiar with a variety of modeling types and techniques, and high-level domain experts involved in key operational decisions. There is always a need to establish a "vocabulary" so that domain experts can effectively describe their problems and misunderstandings can be kept to a minimum, and also so that modelers can elucidate the types of models that may be appropriate. Because of business confidentiality concerns, some sort of nondisclosure agreement is typically required at this stage. In our particular project, we were able to identify two projects that had potential for impact in the business. The first was a business planning model that could be used to assess the economic potential of a particular business opportunity under consideration. The second was an explanatory model to understand the growth of the RHIO over time with a view to improving the utilization of resources. At this initial stage, the appropriate type of model was fairly clear for each of these cases (a flexible cash-flow model for the first situation, with the potential to add stochastic elements later, and a Monte Carlo simulation model for the second), but knowing what data to collect and how to structure the specific details of these models remained open. A key requirement at this stage is to clarify the models' precise objectives in order to support the organization's goals.

Step 4: Create Prototype models
Prototype models can aid communication and further explain the utility of modeling. Such models, typically populated with hypothetical data, can help to establish context and give an initial proof of concept. The modeler should remain flexible at this stage and make simplifying assumptions to limit the amount of detailed data that is required. Furthermore, the modeler should not become too vested in one particular approach since it is likely that the model will require substantial changes. In many cases such models may be discarded – they have served their purpose if they have improved fundamental understanding of the underlying problem. Actual building of such models leads to further understanding of the operation, and exposes many issues including data availability and knowledge of particular parts of the business. In our case, while the final models are likely to be more sophisticated, the prototype models were implemented in simple spreadsheets, each of which allowed a description of the key components of the underlying problem.

Step 5: Presentation of model to domain experts
The purpose of follow-up visits is to demonstrate the model to the domain experts, to validate (or invalidate) the hypothetical data that were used in the model, and to determine what parts of the prototype model require refinement, reworking, or replacement. It is important to walk through each piece of the model to ensure that its structure seems realistic to the domain experts. In many cases, these discussions

can lead to a complete rewriting of the model, or even to a change of the type of model being used. It may be necessary to update the model to address new questions, or to add features that had been not communicated by the domain experts. At this stage one should also address uncertainties and ascertain where the model data may be subject to significant variation.

Step 5: Model refinement
The refinement stage generally requires multiple presentations to the domain experts, each of which incrementally improves understanding of the actual operations being modeled as well as the quality and detail of the model itself. In many cases, the model can be given to the domain expert to establish comfort in using the system while it remains relatively simple and when immediate feedback is useful for modifications. Furthermore, this helps to teach the domain expert how to use the final model.

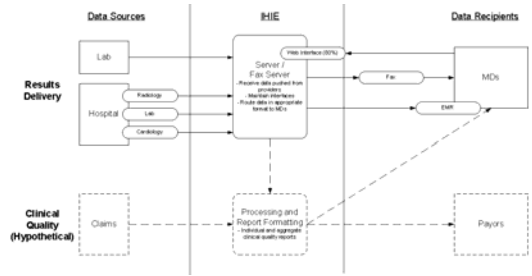
Discussions at this stage may lead to discovery of new opportunities for modeling, as much of the groundwork, vocabulary-building and trust between the parties has been established. Such discussions increase the ability to respond to new opportunities, as they clarify the issues of importance and lead to deeper questions regarding operations and improvement policies.

Step 6: Iteration
Ongoing interaction with IHIE allows the modeling team to better understand the business process and make subsequent refinement in the types of models chosen as well as to ascertain agreement with, or revision of, selected model parameters. The process is complete when the domain expert (IHIE) finds the models useful for business planning and pricing.

Results

We have implemented a simple model of clinical messaging (for IHIE) that is formulated in an Excel spreadsheet which utilizes VBA (Visual Basic for Applications) to handle the discrete event simulations. We outline this model below, but note that we are currently in the model refinement stage and that further work is necessary before a final operational model is complete.

As depicted in Figure 1, this RHIO has information-providing organizations (laboratories, radiology services), an intermediary processor, and data recipients. Information can be sent to the data recipients via electronic messaging or fax, depending on the preference of the recipient group.



Key elements of the model include the data source/data recipient entities, the mediating organization and the relationships among the participants. In the case depicted in Figure 1, centralized functions include identity matching and results routing.

Our model is an abstraction that currently contains two collections of entities, namely laboratories and clinics. It is understood that the geographical layout of labs and clinics affect the growth of a RHIO. These geographical relationships are represented in our model by an inter lab and clinic communication matrix, which is defined as the number of messages that flow between each lab and clinic pair.

Laboratories (labs) are the payers in this model. They receive requests for tests/procedures and need to provide results of those tests as messages to a particular clinic. (It may be the case that the messages can be provided to other entities as well, but we currently understand this not to be the case). We note that a lab may be physically located within a hospital, or within a clinic, or may be an independent facility. Regardless of this, we will understand each of these to be a lab. It is not clear that this abstraction is limiting at all.

Clinics receive reports from labs, and may simply be a doctor's office, a clinic, or a hospital. We treat all such requesters in the same manner, although the number of requests made from different clinics may vary dramatically in the model.

Each message travels a path from a single data source (lab) to a single data recipient (clinic), following a request from the clinic for a procedure at the lab. It is assumed that the number of such messages is known a-priori, but that decisions made by clinics and labs within the model may affect the distribution of the messages.

Currently, the main decision made in the model is whether a lab will join the RHIO. Initially, labs incur a high (lab specific) cost per message. If a lab joins the IHIE alliance, there is a fixed charge (subscription fee) plus a (lab specific but reduced) cost per message. The fixed charge is a tiered cost based on expected annual volume of messages, and whether the message is sent electronically (web) or via fax. The model determines the annual savings that may accrue if a lab joins the IHIE alliance, and if this is positive at the decision time, will do so.

The model assumes that once a lab decides to join the alliance, all messages will go through IHIE via one of two methods – web or fax. A lab's cost of sending a message using the web system is cheaper than sending the message via fax, but it is clinics which have the option of choosing which method it prefers when requesting results. Since only a fraction of message types can be sent using the web (i.e. some results may not be mapped into the CM system), each lab-clinic pair has a predetermined maximum percentage of messages than can be sent using this method. This corresponds to the limited functionality of the electronic mapping system, which we estimate is able to facilitate around 90% of all messages.

Clinics do not join an alliance, but their behavior is governed by two events, namely "Time first used web messaging" and "Time when it becomes fully web compliant" that affect the proportion of clinical messages the clinic requests via the web. Both are a function of the volume and percentage of messages that are received through IHIE attached labs. A clinic only decides to start using the web interface when a new lab decides to join the alliance, although it may decide not to if the volume of IHIE messages is small. While the first time is determined as soon as the first message is sent via the web interface, the latter time may speed up if more labs decide to join the alliance. Once it becomes fully web compliant, the clinic is assumed to use the web to its maximum allowable potential.

It is believed that the state change caused by a lab's decision to join IHIE will also result in clinics redistributing their messages, causing all other surrounding labs to lose a small percentage of their messages to the joining lab. Reasons behind this positive reaction include receiving results in a timelier manner and in a more consistent format. This redistribution of messages will be part of a new state, from which successive labs will make their decision to join IHIE.

The OR model initially has no labs in the alliance and no clinics using IHIE. Using a time driven event list, each lab decides whether it should join the alliance. If a lab decides to join, then each clinic redistributes its messages and decides on the percentage of messages that are received via the web, based on this "state" change. Thus actual cost savings may be different from the estimated cost savings that the lab used to make its decision. The model allows for labs to "reconsider" their decision at a later time if they decide not to join the alliance and also allows collections of labs to join at the same time. However, labs that have previously chosen to adopt IHIE's services do not reconsider their decision, as this is believed not to be a prominent issue.

Examples of the utility of the OR model

Based on data in our OR model that approximate IHIE's per message cost as well as what we consider to be reasonable estimates at this time, the results show a clear financial advantage for labs that choose to make use of IHIE's messaging service, which will propel them to start using IHIE services. The savings vary from several hundred to several thousand dollars annually.

The variability in per lab savings arises from factors including the maximum percentage of messages that can be communicated via the web, the (annual) volume of messages per lab, the time at which a lab decides to join IHIE, the geographical relationship/competition between a lab and other labs and the speed at which a lab's customer clinics become fully web compliant. The OR model can demonstrate all these effects, but we simply outline below two possible scenarios of its use.

<u>The first mover's advantage</u>

In the OR model, it is possible for a lab to gain "first mover's advantage", an added financial benefit if a lab decides to join IHIE earlier on, rather than later. What gives rise to this first mover's advantage is the fact that a clinic's redistribution of messages is in a joining-lab's favor. Although this advantage will decrease as more and more labs begin to join IHIE, we think a smaller percentage of messages will be distributed away from these labs as they have had more time to establish themselves as users of CM.

The OR model shows that this advantage does exist to some degree, but that the advantage is not directly proportional to how long a lab has been in IHIE. This advantage is affected by a lab's volume of messages, and that of its competitors. If competition is high, there is a small chance that a lab may eventually end up with a lower volume of messages than what it first started out with. Clinics may also put pressure on other labs to use IHIE services, as they discover the benefit of consistency, speed and efficiency.

Sequence of joining

There is a correlation between the sequence in which IHIE approaches labs, and their final decision to join IHIE. The OR model has shown that this is particularly important when considering small specialized labs, which not only have a lower volume of messages but are also unable to use the web as much as other labs because much of their market is involved in specialized tests. The OR model demonstrates that such clinics are more likely to join IHIE when they are approached at an earlier stage.

Discussion and additional model considerations

Recent presentation to IHIE of results from the prototype model led to a significant information exchange and increased understanding of the problem. Such exchange would not have been possible without the OR model. Key features that need to be incorporated into the refined model include: a threshold value for joining the alliance to model resistance or alternative priorities of the potential member; the fact that the numbers of messages being transmitted in the model are much smaller than the actual flows occurring now; a modified cost structure; a larger and more diverse set of clinics; and work flow issues at the clinics limiting model choices.

Preliminary approaches to RHIO configuration assumed stable and complete participation by an organization within the alliance. This assumption has to be refined, as departments within a larger organization may have more or less need to participate in the alliance, and may participate in information exchange at different rates.

We believe a model based on distributions of numbers of messages and the percentage of messages using electronic means is a good approach to pursue. The model needs additional features, as well as the addition of uncertainty, which presently is represented by simple distributions or mean values.

A drawback of the current model is that the *ad hoc* behavior of both entities is subject to many simplifying assumptions. However, the current scheme could be incorporated into a more sophisticated simulation model to address questions like: in what order should the labs join (or in what order should IHIE pursue the labs)? What is the effect of changing the per-message charge or the fixed charge? Can we incorporate these "functions" into an "epidemiology" type model (Monte Carlo simulation) to predict how IHIE would grow, and to display the results in some graphical/map-based format?

Conclusion

Operations research is aptly named – it is not necessarily the final model that is of importance, but the process of modeling itself – discussions, modifications, enhancement and refinement are all part of research into a particular operation. Sam Karp, from the California HealthCare Foundation, urges a strategy of strategic incrementalism, to allow decision making about health information exchanges to proceed in a trial-and-error fashion. OR models have the potential to make this strategy useful and to insure that each decision contributes to operational and strategic goals of the health information exchange.

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