Preparedness and Response
New Roles and Responsibilities for IT

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1. Introduction

While historically focused on back office transactions, Information Technology and its ubiquitous presence are now part and parcel of the global business infrastructure and workflow processes. In an increasingly connected world, the need for seamless performance by technology, communication networks, databases and associated public and private processes is no longer a luxury, rather it is a necessity. As such preparedness and response, which at one time were viewed as a fringe roles for IT, is now the new mantra for success.

It was however not in the distant past that the utility of IT was being questioned. Carr (2003) ignited a debate with his article "IT Doesn't Matter" and brought the discussion about the role and value of IT to the forefront. This article spoke to the concerns of the time. The dot-com bust was still fresh in everyone's mind. Carr's assertions let loose a flurry of activity, mainly by IT practitioners and professionals, to justify the relevance of IT for organizations. His paper generated commentary from Industry leaders extolling the value of IT. Their assertions however were based mainly on individual experiences and anecdotal evidence. The strong response to Carr's article suggested that his thesis had hit a nerve. After the initial reaction abated, researchers took on Carr's comments as a research challenge and started to address the question: Does IT Matter? And, more importantly how does IT matter? One of the early streams of work used a case study, qualitative approach. Using primarily an ethnographic-descriptive orientation Thomas Friedman in 2005 published, "The World is Flat." Friedman's work focused on information technology driven emerging economies like India and China and extrapolated from there the changing roles and responsibilities for IT. His analysis was centered on the observation that IT gains prominence by leveraging the existing infrastructure and the process was hastened by the ten flattening events: Collapse of the Berlin Wall, Netscape, Workflow software, Outsourcing, Offshoring, Uploading, Supply-chaining, Insourcing, In-forming and Mobile telephone/technology (Friedman, 2005). Using IT as a catalyst, these game changers were redefining the relationship between the developed and the developing economies. Changing the rules of engagement and associated expectations was indeed flattening the global business playing field. In a very similar time frame, Andrew McAfee and Erik Brynjolfsson undertook a comprehensive study to empirically evaluate whether investing in IT makes a competitive difference (HBR, 2008). This study included all publicly traded companies (on the NYSE) from the 1960s to 2005. After discounting for potential confounding factors like mergers and acquisitions, opening of global markets and R&D efforts, their findings documented that investing in IT gives companies a distinct competitive advantage and is an important determinant of success. Interestingly, their findings translated across industries. McAfee and Brynjolfsson attributed their findings to how investments in IT accelerates the pace of competition by digitizing both products and more importantly processes within organizations. IT benefits were detailed via various financial measures, EBITDA and others for individual organizations and via changes in market based competitive dynamics among companies.

Starting 2009, the general consensus was once again that IT matters. In this paper (keynote address), the objective is to delve into critical success factors for IT in today's turbulent times. In the networked world IT is ubiquitous, but increasingly diffused within the various

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functional areas of most organizations. While standalone organization-centric installations still exist, increasingly, IT is seen as part of a highly interconnected Information Supply Chain (ISC). Using ISC as a central tenet, we draw upon projects conducted in the Healthcare sector[1], one with a strategic focus and the other with a more tactical/operational focus, to extract observations on the new roles and responsibilities of IT. Healthcare is used as the backdrop since in the US this sector now accounts for 20% of the GDP and is presently undergoing rapid transformation to redefine itself. Lessons are extracted from the two projects and provide a basis for proposing a set of empirically testable propositions that can help us define and refine IT roles and responsibilities.

2. Information supply chain – Relevance, Value and Availability[2]

IT is increasingly moving away from being an independent standalone system it is now more accurately characterized as an Information Supply Chain. ISC takes an information-centric view of supply chains, where information is not only used to support supply chain operations, but also to create value for customers and enable business partners to collectively sense and respond to opportunities in a networked eco-system. Creating value in the ISC involves gathering, organizing, selecting, synthesizing and distributing information. In so doing, ISCs are responsible for providing secure, confidential, reliable and real-time access to heterogeneous information, while ensuring that the right information is delivered to the intended recipients at the right time. Recent disaster events such as the Japan earthquake have highlighted the need for and value of ISCs by exposing the vulnerability of supply chains to demand surges and supply disruptions.

Supply chain vulnerability is defined as (Rice and Caniato, 2003) "an exposure to serious disturbance, arising from risks within the supply chain as well as risks external to the supply chain." When IT migrates from a stand-alone set up to an ISC orientation, it becomes sensitive not just in terms of its capabilities, but also with regards any external changes. Resilient supply chains need to be responsive to demand surges and supply disruptions resulting from internal and external vulnerabilities. Mitigating supply chain vulnerabilities requires a mechanism that allows for continuously sensing the environment, detecting existing or anticipated vulnerabilities, and responding to these vulnerabilities in real time through information sharing and collaboration. Decision-making in these "sense-and-respond" systems is further complicated by the fact that the decision makers' knowledge of the space states and actions is incomplete, and the cost of errors is very high. It is therefore imperative that going forward IT has to play a proactive role and have the ability to evaluate alternative decisions prior to taking any corrective actions in real time. These issues related to high levels of information sharing, real-time responsiveness, and collaboration dictate an information-based view of the supply chain.

Table 1. Differences between traditional supply chains and Information Supply Chains (Arora, Raghu and Vinze, 2010)

Traditional Supply Chain	Information Supply Chain
Linear sequence of activities with defined points of inputs and outputs.	Network of information sources and sinks.
Physical assets used up in consumption.	Digital assets not used up in consumption.
Economies of scale reachable only by increasing the number of goods produced.	Small companies can achieve low unit costs of production and services.
Companies usually constrained to one market.	Companies can provide value in disparate markets.
Characterized by high transaction costs.	Low transaction costs.
Forecast driven.	Demand driven.

[1] This paper draws upon research conducted over a six-year period and is still ongoing. The constituent projects had multiple participants. I would like to specifically recognize: Lynda Applegate, Hina Arora, Orneita Burton, Minu Ipe and Raghu Santanam for their contributions. The work was supported in part by grants from the Maricopa County Department of Public Health, Arizona Government IT Agency and the Governor's office and IBM Corporation. This keynote draws from technical and research papers, presentations and case write-ups that resulted from this body of work and is indebted to his research collaborators for their contributions.

[2] The ISC notion was developed in conjunction with a project on Autonomic Computing and was supported by IBM Corporation. Principal researchers for this project were: Hina Arora, Raghu Santanam and Ajay Vinze.

Given the above characteristics of ISCs (Table 1), it is interesting to see how this would translate in sectors as diverse as Services, Finance, IT and Healthcare. Table 2 compares ISC characteristics across these three domains from the organization, process and technology perspectives. Consider an IT network for instance. The network could be made up of several workstations, servers, routers and printers. Workstation users in this scenario are not only users of information (such as checking the print queue, or looking for an idle machine to run a complex job), but also creators of information (such as a submitted print job). Such an ISC will not only use information to remain functional (say, by monitoring for attacks), but also produce value for the customers (say, by alerting the user of an update or system shutdown for maintenance). As should be evident from this simple example, in order to create value, the ISC should be capable of gathering information from multiple sources,

Table 2. ISC characteristics in three Domains (Arora, Raghu and Vinze, 2010)

Characteristic	**Domain**		
	IT	**Finance**	**Healthcare**
Stakeholders	System administrators, users	Stock markets, shareholders	Healthcare providers, patients
Information Characteristics	Defined standards, high volume of information, real-time or batch processing	Relatively well defined standards, high volume of information, real-time information processing	Heterogeneous standards or lack of them, high volume of information, real-time information processing
Business Objectives	System availability, reliability, application performance, security	Timely transaction execution, real-time information feed and delivery, security, reduce trading cost, maximize returns	System availability, reliability, security, confidentiality, real-time information feed and delivery
Constraints	Cognitive limitations of system administrators, limited resources	Information processing, discerning macro economic trends and analyst information	Cognitive limitations of providers, limited resources
Resources	CPU availability, memory availability, intrusion monitoring data	Stock prices, options, capital, credits	Beds, medical staff, medicines, vaccinations, epidemic surveillance data
Information node characteristic	Peer-to-peer or client-server configuration	Peer-to-peer	Peer-to-peer or client-server configuration
Domain specific issues	Gathering and synthesizing requisite information, false positives and false negatives	Trading costs	Gathering and synthesizing requisite information, false positives and false negatives
Business Value of Autonomic Approach	Freeing administrators of mundane tasks, facilitating intrusion detection, improved services for users.	Synthesizing and responding to market trends on real-time basis	Enabling collaboration among providers, facilitating epidemic control, improved quality of care for patients.

compiling complex data, and making appropriate recommendations. In the case of IT networks, the system administrator traditionally did this. However, due to bounded rationality and cognitive limitations, human administrators can deal with only simple decision making tasks and small amounts of information. In fact, this is true of handling disruptions in other dynamic decision-making environments such as finance and healthcare as well. Concepts across these three varied domains share commonalities in decision-making processes as each of them demonstrate the need for dynamic decision-making.

The healthcare system can be characterized as a collaborative endeavor between physicians, patients, healthcare organizations, insurance companies, laboratories and public health that are intricately connected in a healthcare information supply chain. While the IT ISC deals with IT resources such as memory and CPU usage, the healthcare ISC deals with healthcare resources such as beds, medicines, vaccinations, and hospital staff. Data in the healthcare ISC typically pertains to the patient in terms of health records, medical images etc. The healthcare ISC can create value for the patients by ensuring patient data is available to the right entity at the right time, monitoring for epidemics, and optimizing resource allocation during an epidemic.

This can be challenging and requires strong inter-organizational collaboration in real time that is best handled by an effective information system and a balanced communication plan. Differences in the three domains highlighted in Table 2, allows a comparison that makes salient information characteristics that hold across domains when IT is viewed in terms of an ISC, specifically: information relevance, information value, and information availability (Ipe, Raghu and Vinze, 2010).

Information relevance: Health systems and processes are designed to detect both natural as well as intentional outbreaks of diseases. To accurately identify the causal agent in an outbreak, relevant information is necessary. In the case of intentional outbreaks, information should not only guide the containment of the outbreak but is also necessary to apprehend the perpetrators. In reality, it is extremely unlikely that optimality of information relevance is attained: costs and difficulties in attaining this information tend to be very high. Thus, sub optimality often becomes a satisficing solution with health response to emergencies often driven by inadequate information. The results of such decision making (with distorted or incomplete information) carry the threat of poor outcomes, regardless of whether the distortion was created by the intentional choice to adopt satisficing solutions (Lichenstein et al. 1978) or the unintentional inconsistencies in the information acquisition process (Nelson et al. 2005).

Information value: The value of information relates to its ability to affect decision-making. Health emergencies create situations that are bounded in time and space by specific individuals that result in hindering the effectiveness of decision makers. This condition is referred to as information specificity. Two aspects of information specificity, knowledge specificity and time specificity present additional challenges (Choudhury and Sampler 1997). Information that has high knowledge specificity can only be acquired and used by individuals who have the expertise and the skills to make the information valuable to decision making, while information that is high in time specificity loses its value if not captured soon after it originates (Ipe, Raghu and Vinze, 2010). In public health emergencies, the timeliness of information is very critical to decision making. For an intentional outbreak, the information needed to identify and apprehend perpetrators may only be available in a limited window of time. Also, information that could have led to the prediction of outbreaks becomes irrelevant once the event commences. Because of the highly specialized nature of disease surveillance, there could also be situations where the information is available but experts with the necessary knowledge to interpret it don't have access to it for decision-making.

Information availability: Satisficing decision-making in a healthcare context often stems from the unavailability of critical information from the surveillance environment. Previous research has characterized conditions under which information is not available for decision making as uncertain (General Accounting Office (GAO) 2004), asymmetric (Grossman 1981; Smith et al. 1992), imperfect (March and Simon 1958; Rasmusen 2001), and incomplete (Weber 1987; Rasmusen 2001). All of these conditions exist in healthcare emergencies, because information needed to understand the outbreak is not captured in a surveillance system, is communication between agencies, when the information is not known to all parties at the same time, and questionable information quality or willful acts to hide information (Ipe, Raghu and Vinze, 2010).

The information structures described above not only characterize the challenges of decision-making in the healthcare context, but also points to the potential design and implementation imperatives associated with IT in general.

3. Strategic and Tactical challenges for IT

Transforming Arizona's Healthcare System[3]

In 2005, Governor Napolitano took the lead in prioritizing the need for quality and efficiency in the delivery of health care with her Executive Order to create the Health-e Connection Roadmap. Arizona had some unique challenges in the health care arena. In 2005, Arizona was the second fastest growing state in the nation. A population of 5.7 million with a growth rate of 3.5% posed a significant challenge to the health care delivery resources of the state. The geographical spread of the state's population compounded this challenge. About 76% of Arizona's population resided in Maricopa and Pima counties, providing opportunities for developing regional and state-level data exchange. However, with each of the other 13 counties containing less than 4% of the state's population respectively, there were numerous challenges with access to health care in rural areas as well as the in the state's 22 tribal nations. Arizona issues mirrored opportunities and challenges faced more widely in the US. The state CIO, Chris Cummiskey was tasked with providing the IT strategy for facilitating this process. The Roadmap project was initiated and was a key strategic initiative for the state, and a bold step to address the various problems afflicting the health care system. The Roadmap development process represented an innovative public-private partnership approach to policy making. The State, coordinated by the Government Information Technology Agency (GITA), had facilitated the Roadmap development process by building a coalition of partners from a statewide representation of stakeholders in the health care arena. Developing the Roadmap within the six-month time frame identified by the Governor – a project involving almost 300 volunteers.

On April 4, 2006, the Arizona Health-e Connection Roadmap was presented to the Governor. The Roadmap contained broad guidelines to develop an infrastructure that would facilitate the electronic exchange of health information within a span of five years. The Roadmap project became a very strategic momentum building educational forum as well as it produced a document that people felt really good about. That was important. Everybody accepted that document. It gave the general parameters and allowed for the details to be worked in as the project got underway and people started working together. Everybody realized that this was a legitimate process that achieved a legitimate result. The Roadmap addressed the "what, when, why and who" of adopting interoperable electronic health records. The "how" was left to the implementation teams that would subsequently work on the project. Initiatives presented in the Roadmap were considered from the perspectives of urgency and feasibility and were to be implemented in the context of Medical Trading Areas (MTAs – geographical areas where a defined population cluster receives its medical services). The Roadmap distinguished between Health Information Technology (HIT) and Health Information Exchange (HIE). HIT was defined as the organizational deployment of technology to support business and clinical practices and included electronic medical records, administrative systems, and workflow systems among others. HIE was defined as the infrastructure that enabled data sharing between organizations. The initiatives proposed in the Roadmap were a combination of both HIT and HIE.

If the implementation of the Roadmap had to ultimately be successful in Arizona, the self-interests of several disparate entities across the health care space had to merge with the intent of achieving this outcome. These entities included among others, providers (hospitals, clinics and physicians) and payers (health plans), who operate oftentimes in a competitive space and who have very definite issues related to data ownership and data exchange. Physician resistance to changing their IT systems or investing in new systems, bridging the gap between advanced adopters of IT and those organizations that are primarily paper-based is a

[3] This section is extracted from our HBS case (#N9-808-072) – Authors: L. Applegate, A. Vinze, T. S. Raghu and M. Ipe – the project was conducted from 2005-2007. This project was supported by the Arizona Government IT Agency and the Governor's office. Principle researchers for this project were: Orneita Burton, Minu Ipe, Raghu Santanam and Ajay Vinze.

significant challenge. While many physicians were well aware of the benefits of IT adoption, the costs involved were prohibitive for many small and medium sized practices. So a major hurdle for the Arizona Health-e Connection would be to develop incentive systems or other structures that would motivate physicians in large numbers to digitize their health record systems and invest in technology that allows for health information exchange with other health care organizations.

In developing the Roadmap, the leadership team felt that Arizona had not only set a strategic direction for the future of health care delivery in the state but had also demonstrated the ability to bring together key stakeholders from both the government and the private sectors to create a common vision. Through an innovative public-private partnership approach in building the Roadmap, the government had been a catalyst for change without owning the process or the outcome directly.

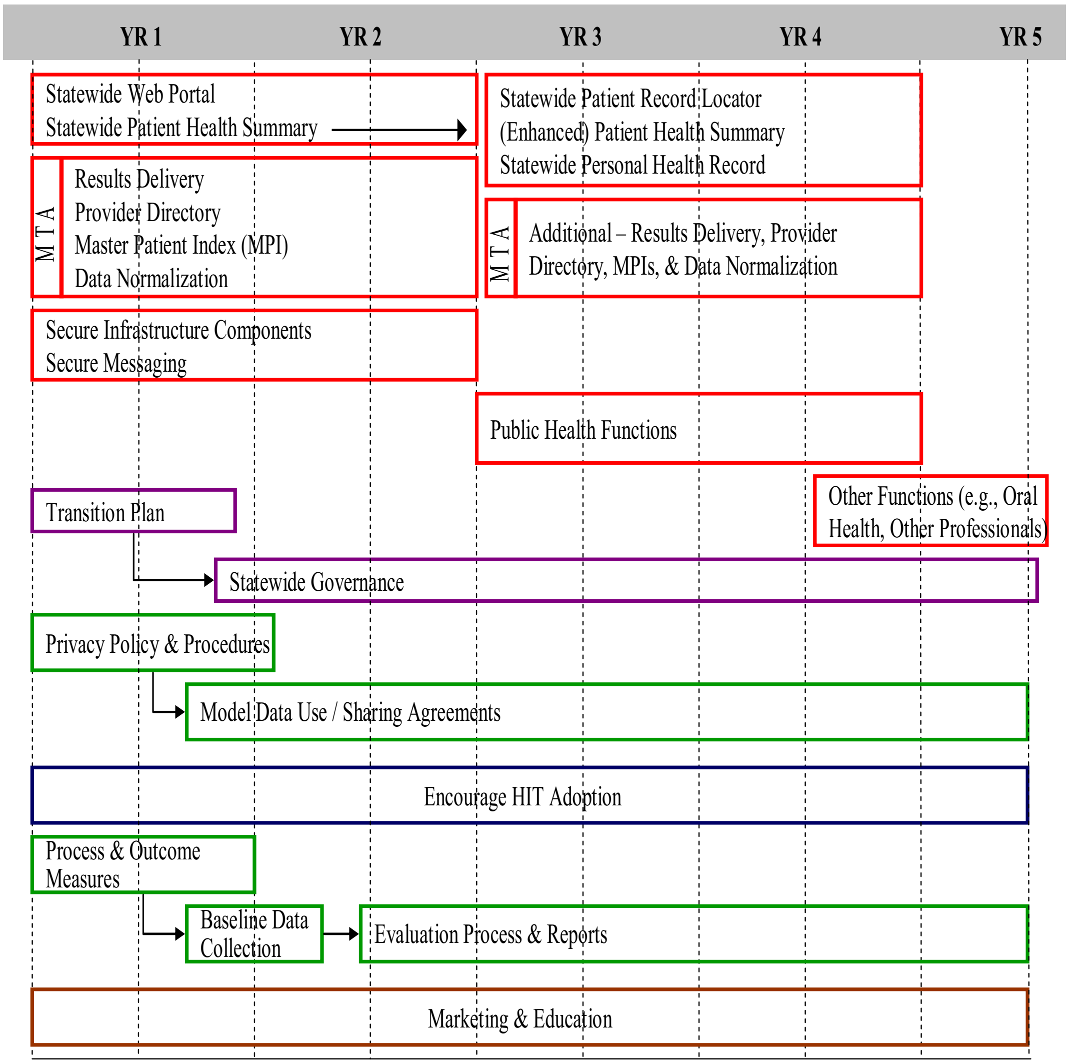

Figure 1. Roadmap Implementation Timeline

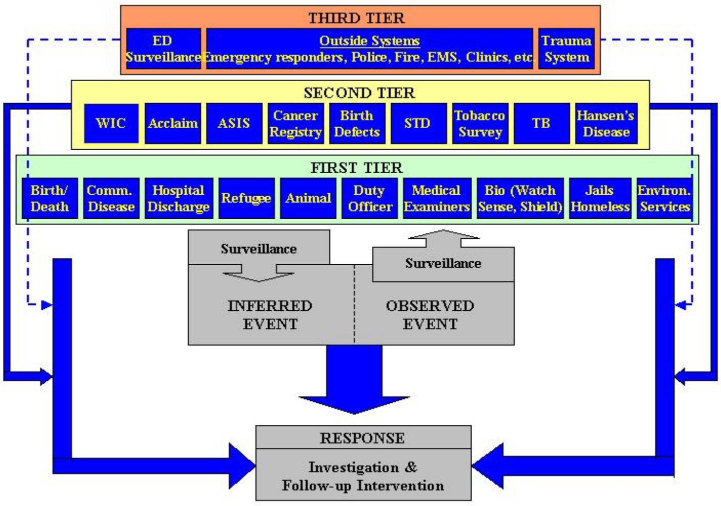

Figure 2. Public Health Overview

Implications extracted for ISC:

- Strategic understanding about the relationships and information exchange between stakeholders needs to be negotiated early on
- Need align roles, responsibilities and incentives among participants
- Important to clarify difference between intra-company IT (HIT) and inter-company IT (HIE)
- A champion with credibility across the ISC is needed to facilitate development of standards

Tactical/Operational Challenges for IT

Dealing with Public Health[4]

Public health is often referred to as the "long tail effect" of healthcare. While hospitals and first responders in the Healthcare industry tackle the immediate effects of a healthcare crisis, public health impacts play out over a very long time period and have a very broad based impact. As a result, Public Health is expected to continually monitor the environment for possible healthcare disruptions and contain the problem before it flows through the populace. Surveillance and response is at the heart of the public health establishment.

Information systems for public health preparedness are emerging as powerful tools to address the information intensive nature of preparedness and response. Developing an appropriate response to a public health emergency requires extensive information sharing and collaboration among a variety of loosely coupled stakeholder organizations. In such situations, information and communication technologies can facilitate the much needed time critical information exchange. If designed and implemented well, IT systems have the potential to significantly enhance the efficacy of decision making during emergencies. Decisions in the public health arena can result in the prevention and an early containment of an outbreak; alternately, if not addressed correctly, it has the potential to result in catastrophic consequences for the community. In such an environment, the design and ownership of an IT system is a potent force that can significantly influence preparedness for and response to an emergency.

Information processes in public health surveillance can be divided along two distinct dimensions: pre-event surveillance and surveillance during the event. Pre-event surveillance refers to the ongoing process of acquiring information from a variety of sources throughout the community to monitor general health and well-being of the population. Several agencies participate in a fairly regular exchange of information with public health organizations. These agencies include: hospitals, the medical examiners office, schools, day care centers, etc. Figure 2 summarizes the layered structure of information sources in a public health surveillance context. A key characteristic of this information structure is the bi-directional nature of surveillance. While public health emergencies may be inferred from the vast amount of

[4] This is an extract from technical reports and research papers related to projects conducted with the Maricopa County Department of Public Health and IBM Corporation – T.J. Watson Research Center from 2006 to 2010. Principal researchers for this project were: Hina Arora, Orneita Burton, Trent Spaulding, Raghu Santanam and Ajay Vinze.

information collected as part of regular activities, an abnormal event may trigger a focused search and surveillance of existing information sources to uncover the root cause of the event.

With this overview understanding of Public Health roles and goals, we next turn our attention to a specific public health event – the influenza outbreak.

Once it starts, an influenza pandemic is expected to spread rapidly. Given the high infection rate of influenza, this can result in a demand surge for scarce healthcare resources such as beds, vaccines, medicines, nursing staff, and doctors to treat those infected and check the infection among the healthy population. In order to combat the epidemic, it becomes imperative to manage these scarce resources and ensure their availability to those that need it the most in a timely manner. IT is typically tasked with this responsibility.

A large-scale public health emergency such as an epidemic outbreak can result in an overwhelming number of human casualties. This can result in a demand surge and associated scarcity of healthcare resources such as beds, staffing, supplies and equipment due to demand surges. Surge capacity is a health care system's ability to expand quickly beyond normal services to meet an increased demand. Cooperating through mutual aid at the regional level can help improve surge capacity. This requires real-time collaboration among various entities (such as hospitals and pharmacies) in the Healthcare ISC. However, the complexity of the resource redistribution and allocation problem can quickly overwhelm human decision makers.

Our research team was activated by the Maricopa County Department of Public Health on two instances. The first was to study systematically how diseases can propagate through populations – this resulted in the development of EpiPlanz. The second engagement was at the peak of the H1N1 outbreak (November 2009 – January 2010) and focused on bringing efficiencies to resource allocation by effectively managing the public health ISC. Both these engagements provided invaluable insights on the changing role of IT.

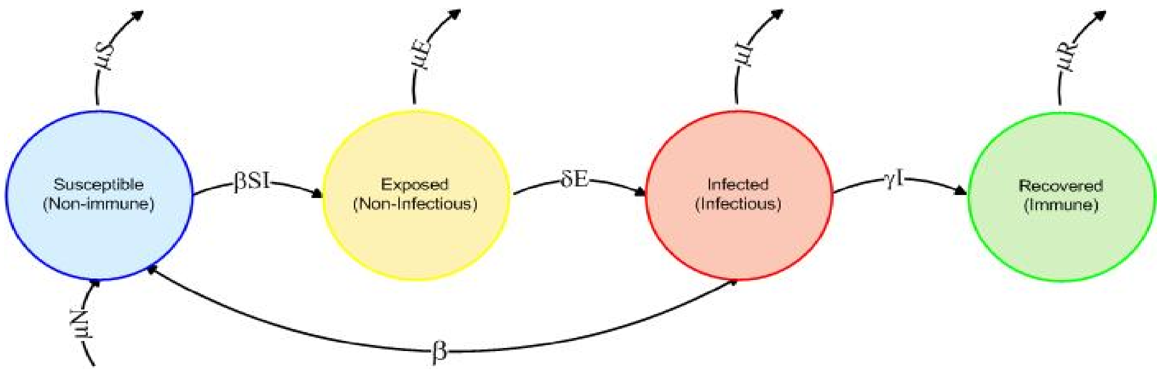

Figure 3. Exponential Nature of Epidemics

EpiPlanz

EpiPlanz was developed (Arora, Raghu and Vinze, 2006) using autonomic principles of self-optimization and self-configuration. The goal was to address demand surges in the context of healthcare information supply chains that have been disrupted by an epidemic. The prototype was a multi-agent simulation system that included all 13 counties in Arizona and also included data from the 7 southern California counties. Using an autonomic computing approach we facilitated resource allocation decisions in responding to public health emergencies. The multi-agent toolkit, Repast1, was used to simulate an influenza epidemic. Regional healthcare entities and associated data were included in the study. Communication and information flows from all entities in the public health supply chain were included, both from a data perspective and how the communicated their resource requirements. This information is analyzed for resource shortages and excesses. A utility-based constrained optimization problem was formulated. Constrained by high-level budget and resource policies the purpose was to find a satisficing solution both when using Pharma and non-Pharma interventions.

H1N1 Vaccine Allocator

The Vaccine Allocator was developed (Spaulding, Raghu and Vinze, 2010) to provide real time decision support to vaccine distribution for H1N1. In November 2009, at the peak of the outbreak, vaccine was in very short supply. Furthermore, there were regulatory directions imposed on the dissemination of the vaccine (priority ranking of recipients) to maximize effectiveness and facilitate herd-immunity where possible. A data-driven solution was developed that reflected the requirements and constraints of all participants in the public health ISC (vaccine suppliers, healthcare providers, patients, schools, nurses, parents, hospitals and others). With an EpiPlanz based understanding of the ISC, the Vaccine Allocator was developed in record time and was the basis for all H1N1 vaccine distribution decisions in Maricopa County. This application of a real time IT ISC solution was credited with saving lives and averting what could have been a very large scale epidemic.

Implications extracted for ISC:

- Need for interagency collaboration – decision making has to be a collaborative process
- Need align roles, responsibilities and incentives among participants and to build bonds of trust related to information exchanged
- Goal congruence among collaborators is critical
- Ability to generate public awareness is crucial to a successful outcome

4. Roles and Responsibilities for IT

With IT evolving to an ISC orientation, it now must be view as a complex ecosystem of multiple interdependent parts from both inside and outside the traditional organizational boundaries. Success in this ecosystem is going to be defined by the stakeholders involved and not by just the base technology, as such it now becomes important that IT professionals now pay attention in equal measure to these two facets. Stakeholders, defined by the Stanford Research Institute (1963) is a "group or individuals without whose support the organization will cease to exist." The role and importance of stakeholders for IT success is well documented for the healthcare domain and is amply illustrated in the exemplar projects described earlier. With this twin responsibility "technology and stakeholders" as a backdrop, we can surmise five critical success factors as IT takes on the challenges of preparedness and response.

Critical success factors[5]

CSF #1: Stakeholder commitment – Securing such a commitment is difficult, this particularly if needs and incentive structures of the participants don't align. IT needs to be cognizant of this and reflect participant values so as to help them work together seamlessly.

CSF #2: Trust building – Trust is widely acknowledged to be important for efficient operation of inter-organizational business. Although, trust formation is now an accepted goal in any network management task – ISC and others, it is inordinately difficult to achieve. For and ISC, a dynamic network, conventional means to build trust may prove inefficient. New inter and intra network roles need to be defined and coordination responsibilities need to be assigned.

CSF #3: Information Sharing – The term information sharing was made popular by the 9/11 commission. Information sharing involves setting up of processes, coordination mechanisms and computer networks to exchange data both tactically and strategically. This requires a new level of openness and will have to jointly address competition and collaboration.

CSF #4: Incentive alignment – This is the driving forces for governance, commitment, compliance, control, trust, risk, and security issues. Information asymmetry within any ISC complicates this issue. Cooperation and collaboration among stakeholders is often predicated on this factor.

CSF #5: Goal congruence – This term is often used when goals are shared between managers and subordinates. In an ISC however, these hierarchies don't exist and congruence results when actions and/or decisions of individual or companies taken in their own best interest present also represents the optimal action/decision set of the group taken together.

Organizations and political boundaries are now being defined in terms of information

[5] A more detailed discussion of these CSF and their association and implications for Healthcare in general and Public Health in particular has been presented in Ipe, Raghu and Vinze (2010).

sharing and collaboration among a variety of loosely coupled stakeholders and organizations. This is an opportune time for the IT industry to reevaluate its role and responsibilities and how it can be an agent for change as we transition to an ISC based economy.

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