Preface

INTRODUCTION

Today, healthcare services delivery systems in many countries across the globe have arrived at the crossroads of two parallel, and sometimes competing, demands. On the one hand, there is the dire need for healthcare services to become more patient-centered while the systems have to reduce rapidly escalating costs and continue to sustain and/or improve the quality of the care being provided. On the other hand, an equally urgent need is for healthcare funders to invest more substantially in emerging healthcare information systems and technologies (ISTs) in such a way that innovations will be used to support, even result in, more meaningful ways of delivering efficient and cost-effective healthcare services to a growing population across the globe. In this regard, numerous researchers (e.g., Abraham et al., 2011; Dohan & Tan, 2011; Gillies & Howard, 2011; Wickramasinghe et al., 2011) have correctly observed that not only are many of the global healthcare services delivery systems facing major challenges of affordability and quality issues, but new systems thinking and innovative modeling approaches are critically needed at this time to better guide the future development of sustainable population-based and patient-centered healthcare services.

In this volume, sixteen (16) papers have been assembled to focus on the larger question of why, how, and what healthcare IT innovations can contribute to improve quality healthcare services at reduced costs significantly, while strengthening patient engagements and transforming traditional clinical practices through the elimination of wasteful, irrelevant, and unnecessary organizational processes. Evidently, this calls on the willingness and need for payers (e.g., insurers and governments) as well as researchers and practitioners to shift thinking from holding onto the traditional approaches in the acquisition, storage, and use of inoperable patient information restricted mostly to independent care providers to focus on interoperable digitized ISTs that can be shared among multi-providers via a team-based approach for the benefits of all patients. The readers of this volume must also realize with Falan et al. (2011) that in order for this shift to take place quickly, the traditional structure of the healthcare organizations and built-in processes must necessarily change with the paradigm shift towards eliminating wasteful and inefficient healthcare organizational processes so as to achieve greater administrative efficiencies and clinical effectiveness in order to yield value to the customers (i.e., the patients).

Even so, new thinking, new approaches, as well as new models have continued to emerge with the possibility of transforming traditional healthcare organizational structures and processes, including many areas of clinical practices, as illustrated by the intense discussions offered by many contributors in different clinical and administrative application domains. For example, new ways of delivering healthcare in terms of pediatric care (Aceti & Luppicini, 2011), chronic disease management (Montazemi et al.,
2011; Wickramasinghe et al., 2011), home healthcare (Mitchell et al., 2011), healthcare supply chain (Buyurgan et al., 2011; Mettler, 2011), biomedical images and clinical diagnosis (Cheng et al., 2011; Amer et al., 2011; Nadathur & Warren, 2011), psychiatric services (Andersen & Jansen, 2011), and/or private practices (Sobol & Prater, 2011) are included in the present volume.

In summary, this volume is organized as follows: first, the rationale of why it is critical to sustain healthcare IT innovations today is highlighted (Gillies & Howard, 2011; Falan et al., 2011). Then, several roadmaps for the healthcare reformers who would like to promote such innovations, including the need for data standards adoption (Buyurgan et al., 2011) and the need to pay more serious attention to organizational factors such as power structure (Andersen & Jansen, 2011), for profit versus not-for-profit ownership status and the size of patient base (Mitchell et al., 2011) are detailed. Following this, attention is turned to various applied innovations such as m-health (Aceti & Luppicini, 2011), pervasive wireless technologies (Wickramasinghe et al., 2011), integrated health information exchanges and networks (Montazemi et al., 2011), as well as ways to benchmark performance and promote change management (Mettler, 2011; Sobol & Prater, 2011). Next, we turn to psychometric measures and decision analytic methods. Here, we will first look at the need for valid and reliable instruments to measure and benchmark success of various health IT innovations and implementations, and more specifically, the Systems Engineering Initiatives for Patient Safety (SEIPS) questionnaire (Hoonakker et al., 2011), and how maturity of specific IST innovations can be measured (Mettler, 2011). We then shift focus to decision analytic models applicable to studying clinical diagnosis and health IT innovations, including the use of Bayesian Networks (Nadathur & Warren, 2011), the application of Neural Fuzzy methods (Amer et al., 2011), and the Evolving Artificial Neural Networks (EANNs) for recognizing overlays, particularly arrows, in biomedical images (Cheng et al., 2011). Finally, we conclude the volume with a look at emerging paradigms of health IT innovations, including a discussion of the various health IT maturity models (Rocha, 2011) and the application of Social Network Analysis (SNA) for a better understanding of IST innovation diffusion as presented in Arling et al. (2011).

### RECOGNIZING THE NEED TO SUSTAIN HEALTHCARE IST INNOVATIONS

The rationale for sustaining healthcare IST innovations has been clearly underscored by Gillies & Howard in the first paper of this volume. Drawing from previous research advanced by Avison and Wood-Harper (1990; Avison et al., 1998), the authors argued that the foundation on driving healthcare organizational transformation, more specifically change management in traditionally organized healthcare systems, must be through the appropriate and clever use of information within the framework of adopting a hybrid (soft/hard) systems thinking and philosophical approach.

Gillies & Howard’s vision begins with instituting good policies to drive innovations in healthcare IT business solutions in the face of the global economic meltdown that is challenging many countries. Here, the aim is not just to cut down on healthcare expenditure, but also to realize the “value” of healthcare services to the patients (i.e., the customers). They termed their framework the M3 process, which combines the best elements from all past techniques, involving several steps.

1. **Policy Implementation:** In which societal goals will drive policymaking. Policy is defined in terms of performance indicators whereas innovations are designed to deliver on outcomes that are governed by key performance indicators (KPIs);
2. **Organizational Analysis:** In which Soft Systems Methodology (SSM) will be used to better define ill-structured problems within the system with the aid of rich picture, resulting in a plan of action and visibility of potential solutions;

3. **Maturity and Competency Modeling:** In which possible improvements are identified for key competency areas for individual staff roles along five stages of performance maturity, namely, novice, learner, competent, proficient, and expert;

4. **Socio-Technical Analysis:** In which the maturity model is further extended to characterize the organization in terms of roles and hierarchies, external drivers, internal motivations and individual prior skills. Ultimately, the result is achieving a matrix showing how the IST maturity model of initial, repeatable (improving), defined (systematized), managed (payback), and optimized stages can be integrated with meaningful use of health IT along three dimensions: information technology, information management, and information governance.

Essentially, the M3 process dictates a developmental path for the evolving maturity implementation of healthcare IST innovations via a complex adaptive approach, and more specifically, the M3 process cumulates both the social (i.e., the people issues, such as their competencies, culture, and perception of technology use and value) as well as the technical (i.e., the infrastructure, functionality, and interface design of the technology) aspects of the health IT innovations and implementation. Past experiences and studies have already shown that healthcare IT innovations, if managed properly, will improve the quality of healthcare services delivered; in this respect, Gillies & Howard (2012, p. 32, 33) further argued: “a combined soft/hard approach can deliver benefits greater than the sum of the parts… The value to an organization derives not from the information system itself but from the new ways of working supported by the technology.”

Falan et al. (2011), another key contribution here, attempts also to rationalize the need to sustain health IST innovations. In their paper, the authors presented a taxonomic analysis of waste enriched with illustrative examples drawn from multiple real world cases relevant to healthcare services delivery. Waste categories (inefficiencies, clinical errors and/or excesses, behavioral waste that are preventable and unethical waste resulting from intentional dishonesty and/or untoward behaviors) as well as root causes of waste (inefficiencies, clinical errors, overcautious or unwanted behaviors, unethical claims) are clearly defined, documented, and illustrated throughout various US-based healthcare cases. Apparently, the same sort of thinking is applicable to any other healthcare delivery systems across the globe. Importantly, it should be noted that unless all such waste is eliminated from the healthcare services delivery systems, costs would continue to rise over the coming years. The idea of waste elimination is not new, especially in the manufacturing sector, specifically, the Toyota Motor Inc. However, it has been more emerging in healthcare and has been grounded in Lean thinking, a concept that is currently being debated hotly among various healthcare academic circles and practitioner communities.

Nonetheless, Falan et al. noted that “a system-wide approach is essential to the elimination of healthcare waste” and that various strategies can further be implemented for different healthcare stakeholders in order to reduce waste. For example, healthcare insurers can promote the elimination of waste by reimbursing for quality performance and reduce premiums for insurance if insurance policies can be sold across state lines. Similarly, care providers can eliminate waste by embedding the concept into their organization’s mission, vision, and strategic plan. Other strategies would be to require care providers to become accountable for their actions or mis-steps and/or reward them for being innovative. For patients, Falan et al. recommended that they should become more skillful and educated in the use of ISTs, be encouraged
to improve on their “health literacy,” be incentivized for adopting healthy lifestyle behaviors, and/or be more informed by providing them with “information about the necessity and costs of medical services.”

More generally, the approach advocated to waste elimination comes in a number of key steps that government, healthcare delivery organizations (HDOs), groups and individual care providers, and even patients can take. As noted by Falan et al., such major steps should include, among other things: (a) the identification of the “precursor of each potential waste”; (b) the analysis and study of current business process designs using “defined detection criteria,” and to see if there may be ways in which such processes can be re-engineered to improve the flow of information and/or actions for care delivery; and (c) the examination of “outcomes” through the use and implementation of healthcare IT innovations that would support and promote safety, efficiencies, and effectiveness of the care delivery process.

ROADMAPS FOR HEALTHCARE REFORMERS

The next segment of our journey for promoting and sustaining health IST innovations is to provide some important roadmaps for healthcare reformers. Here, we begin with the work of Buyurgan et al. (2011) on the development of a roadmap to guide the adoption of GS1 data standards “to improve the efficiency of healthcare supply chain as it did for the retail supply chain.”

The roadmap for GS1 data standards adoption advocated by Buyurgan et al. is layered into three major levels, each with particular characterizing components. For example, in Level 1, to achieve “the minimum full level of GS1 Data Standards adoption,” the use of Global Location Numbers (GLNs) and Global Trade Identification Numbers (GTINs) should be implemented so as to allow the filling out of the relevant provider supply chain databases which should also cover both internal and external supply chain transaction processes. In Level 2 implementation, the use of barcodes or other relevant technologies would be added to ensure that all products would be distinctively identified and captured. As well, Level 1 GS1 Internal adoption should be integrated in an automated fashion into Level 2 capabilities. Finally, the aim of Level 3 implementation is to extend GTIN identifier uses to “the point of patient care” as well as to take advantage of secondary data analysis so as to inform providers as well as suppliers on “expiration dates and lot/serial numbers on products to facilitate efficient recall, return, and outdated product management”.

Altogether, lessons learned through a series of pilot testing to validate and demonstrate the feasibility and practicality of the 3-level implementation model by Buyurgan et al. included: (a) the need for healthcare provider, rather than the supplier, to initiate and move on the GS1 data standards adoption strategy; (b) the need to focus the GS1 implementation for both internal as well as external transaction processes, not just internal supply chain operations; (c) the need to evolve the adoption level by level, rather than trying to do it all at once; (d) the need to use GS1 anchoring to overcome dual numbering challenges as well as other challenges; (e) the need to achieve interoperability among technologies supporting the GS1 data standards adoption and processing; (f) the need for collaboration among vendors and the EDI partners (i.e., suppliers and providers); and (g) the need to recognize the gains from automation.

A second roadmap to guide the successful implementation of health IT innovations is given by the work of Andersen & Jansen (2011), who attempted to apply the new thinking of path creation instead of following the existing traditions of path dependency. In their research, path creation for health IT innovations was found to affect organizational structures and work practices in that the existing central-
ized power structure had to give way to the emergent decentralized structure while a new 3G mobile technology was being advocated and implemented for psychiatric services aimed to serve children and adolescents in Norway.

More specifically, the theoretical model for pushing health IST innovations within the Andersen-Jansen’s study setting incorporated three layers: (1) the material layer; (2) the cognitive layer; and (3) the organizational layer. For the material (artefact) layer, the existing structure was controlled by the Regional Health Authority, which supported videoconferencing through the use of PC via broadband infrastructure whereas, in the emergent structure, a 3G mobile technology was advocated and suggested as the new health IST innovation to be supported. This essentially called for a change in the organizational layer as well as the cognitive layer. At the organizational (task) layer, the change was demonstrated by the need to move from the existing centralized development model based on the traditional telemedicine approach into a decentralized development model anchored to project teams sponsored by top management of the County Health Authority as well as drawing contributions from user, technology, steering, and project groups. At the cognitive (design) layer, the change was demonstrated by the need to move from the existing broadband infrastructure that was part of the National Health Network into the creation of a new path supporting 3G mobile phone infrastructure, thereby serving as a standalone solution. The new path also supports active user engagements and promotes new developmental strategies.

A third roadmap to guide health IST innovations is given by the work of Mitchell et al. (2011), who studied how health IST adoption can be used to improve coordinated care among multiple care providers and what underlying organizational factors impact on such adoption behaviors. According to them, their study “extends population ecology theory into innovation adoption theories by explaining possible competitive advantages of Electronic Medical Records (EMR) adoption within home healthcare.” Derived from the inherent perspectives of biological ecology, the population ecology theory attempts to rationalize, within a specific population group, what the impact of respective environment would be on the organizations. In other words, organizations that cannot compete within the respective environment with other organizations would gradually diminish; therefore, the introduction of new technologies could either work for and/or against the survival of the organizations depending on its successful adoption and impact on the competition.

In their statistical analysis of data representing a US sample of 1,036 home health/hospice agencies, Mitchell et al. found that for-profit status, the time period in which the organization has been operating, and size of patient population all play critical roles as far as health IST innovation adoption is concerned. More specifically, their results showed that “larger, not-for-profit, and younger home health and hospice agencies” are better in adjusting to the adoption of point of care technologies and EMRs. Still, age of agencies did not exhibit a linear relationship with the better innovation adoption adjustment factor. The authors argued intuitively that the curvilinear relationship might be due to the fact that while younger facilities can more easily adapt to changes arising from the health IST innovations, much older, well-established agencies would have the financial means to sponsor and support such innovations, leaving the ones in between having the greatest difficulties to meet the innovation adoption challenge. Similarly, facilities with larger patient census were thought to have the means to purchase point of care technology to better coordinate care among multiple care providers for their patients. Finally, it was argued that not-for-profit facilities would be more willing to reinvest their revenues back into health IST innovations, whereas it might be difficult to justify cost savings arising from such innovations over the long-term in for-profit organizations.
The next segment of our journey on promoting and sustaining health IST innovations is to examine instances of applied innovations in various health organizational settings. Aceti & Luppicini (2012), for example, provided insights into the implementation of mobile health technology within Hamilton Health Sciences (HHS), a large traditional hospital setting, of how the technology impacts on interdisciplinary communications and information sharing patterns among health professionals affiliated with the facility. The results of their study demonstrated a mix of benefits and limitations.

In terms of qualifying advantages, it was argued that the technology supported primarily information sharing through logging into a patient’s medical record. As a result, the benefits pertained mostly to convenience of information retrieval and flexibility of keying in patient’s information, but not for information sharing outside of the patient’s medical records and/or for communication purposes. Indeed, m-Health Technology in HHS was not found to support communications among healthcare providers from the different disciplines effectively as not only were the providers not keen on nor can everyone log into the patient’s medical record easily. Moreover, the system recommended for use had “poor” ergonomic design - that is, the mobile technology requires the use of “sensitive inputting devices,” is also heavy and large in terms of its weight and size, and has limited or very “small” screen.

Finally, it was noted that the integration of health informatics into the organizational workflow had also resulted in changing policies and procedures. User resistance and increased interruptions of the care providers were also challenges for m-Health technology use. As indicated by Kaplan & Harris-Salamone (2009) that failure of the m-Health implementation in this case was due more to socio-cultural issues and would be more managerial in nature than technical.

The presentation of a second applied innovation in this volume is given by the work of Wickramasinghe et al. (2011). Here, a pervasive wireless monitoring device, DiaMonD, was evaluated on a preliminary basis for its support to aid Australian women suffering from gestational diabetes to self-manage. While a number of potential benefits of DiaMonD was noted based on preliminary data such as low-cost as well as ease of use and high provider-patient interaction frequency, the limitation of being unable to compare study results with other potential technological solutions as well as the lack of a rigorous RCT (randomized control trial) for such technology intervention would further restrict the transferability of the suggested solution across different healthcare systems.

Montazemi et al. (2011) provided a third piece of applied innovation in healthcare IT, also for supporting and better understanding coordinated care given to diabetic patients when technology-enhanced communications among various stakeholders as well as patients can be achieved. Indeed, these researchers found that while eHealth technologies have the potential to link care providers in terms of information sharing and exchanges, the patients were nonetheless “disenfranchised” from such “integrated” health-care information systems. This is true despite the fact that most patients could also be well connected to their care providers via personal contacts. As such, it is suggested that policymakers should focus on investing in integrated information systems that would “support patients’ participation in coordinated treatment plan decision-making.”

The final piece of work discussed in this section relates more specifically to benchmarking the adoption and use of health IST innovations in private medical practices (Sobol & Prater, 2011). In this work, data showing ratings across a series of common and emerging business as well as medical information technologies (ITs) such as electronic bar coding, optical scanning, local area networks (LANs), hospital mainframes and intranets, handhelds, voice recognition, AI/knowledge-based systems, email, video-
conferencing, telemedicine, interactive systems, digitized imaging and medical records were compared analytically among care providers from both the US-based and Taiwan-based healthcare systems. Beyond the technologies, barriers to IT use, and other characterizing factors (e.g., number of physicians in practice, years in practice, whether a practice takes Medicare but not Medicaid, and size of practice) were also considered. Results of the data analysis showed that while physicians cannot be considered as the driving force for IST adoption, the use of ISTs can help reduce physician workloads as well as the need for physician time regardless of the country they practice medicine, that is, US or Taiwan private practices. It was also concluded that Taiwanese doctors tended to use more Medical systems than US doctors, whose primary IST uses were for transaction (business) purposes. In Taiwan, IST systems were used for both transaction as well as informational purposes. Not surprisingly, adoption of ISTs was found to be higher in Taiwan – this is rationalized by its healthcare nationalization focus and the standardization of EMRs (electronic medical records) in Taiwan.

PSYCHOMETRIC MEASURES AND DECISION ANALYTIC METHODS

The next segment of our journey on promoting and sustaining health IST innovations is focused on instrumentation development to measure key constructs for IST innovation adoption as well as on a variety of the decision analytic methodologies applicable to diagnostic and clinical eHealth studies.

Hoonakker et al. (2012), for example, offered intelligence into the process of instrument development to measure user satisfaction in CPOE/EHR implementation within the ICU setting. To construct their pre-implementation and post-implementation questionnaire, they started with identifying items and drawing them from available scales that have been tested to be valid and reliable from past efforts. Following this, they pilot tested the pre-implementation version of the instrument, made relevant changes as a result of the data analysis and begin work on aggregating and compiling the post-implementation version of the questionnaire. They again pilot tested the post-implementation questionnaire, making the second round of data collection and analysis, yielding further revisions to the questionnaire. A third round of data collection and analysis yielded a valid and reliable questionnaire, the Systems Engineering Initiative for Patient Safety (SEIPS) survey instrument, containing 29 differing clusters of response categories in total.

The next contribution by Mettler (2011) offered readers insights as to how the breadth and complexity of supplier relationship management (SRM) systems for Swiss hospitals may be evaluated with an instrument based on the conceptualization of the IST maturity model. The author reviewed IST maturity models and mapped the various criteria or reference points (items) used for evaluating the maturity of SRM systems into four different dimensions, specifically, that of work environment (i.e., organizational culture and behaviors), work practices (i.e., organizational processes), IT infrastructure (i.e., hardware, software and networks), and worker competencies (i.e., employees’ skills and expertise to implementing the SRM). The key contribution here, therefore, is the development of a “prototype” measuring scale that was tested for validity and reliability to be used as an assessment tool for SRM systems with detailed descriptions of 5 different levels of SRM maturity that could be discriminated: (1) Not focused SRM system, (2) Intra-functional focus of SRM system, (3) Inter-functional focus of SRM system, (4) Inter-organizational focus of SRM system, and (5) Service focus of SRM system.

Nadathur & Warren (2011) focuses on using Bayesian Networks (BNs) as a technique for modeling the administrative hospital datasets for long-term stroke patients. Their study focus was to compare and contrast the complex patterns of stroke patients recovery, all of whom were admitted and/or transferred
to Stroke Care Unit (SCU) v. non-SCU teaching hospitals. It was observed that patients treated in SCUs (who primarily received “acute” care) tended to be younger than those treated in non-SCU tertiary hospitals (who may often be given “elderly” care). Not surprisingly, they also found that length-of-stay (LOS) was longer for patients in non-SCU teaching hospitals v. those in SCU teaching hospitals, with patient complexity and stroke subtypes having an impact on LOS. The authors conclude that BNs is a “powerful and accessible tool” that could be applied more profusely to understand the dynamics underlying hospital administrative datasets.

In contrast to BNs, Amer et al. (2011) applied a novel neural fuzzy technique to classify potassium ($K^+$) disturbances diagnostically. In the paper, the authors proposed the use of NEFCLASS (NEuro Fuzzy Classification), a combination of fuzzy logic and neural networks, as an efficient tool for classifying medical disorders. Their results showed that NEFCLASS not only provided accurate diagnosis, but also clinically acceptable sensitivity and specificity measures when compared to other techniques currently being used (e.g., Wu et al., 2003). Essentially, the NEFCLASS approach used was able to discriminate among 5 classes of hypokalemia: normal, critical stage, mild stage, moderate stage, and severe stage. Performance results showed that use of this analytic approach empowered caregivers not only to provide accurate diagnosis, but also to facilitate their choice of appropriate treatment for hypokalemia patients.

The last contribution in this segment is the work of Cheng et al. (2011), who presented an approach to combine image and feature analysis as well as computational intelligence-based techniques for “arrow discrimination” in “annotated” or author-marked biomedical images. The need to detect and retrieve these “annotated” highlights in biomedical images may be critical for improving understanding of the information embedded in these images.

Briefly, Cheng et al. developed an algorithm for arrow detection in biomedical images and their experimental results appeared to show high success rates in discriminating images containing arrows from those having no arrows. The key contribution here is then the algorithm for the segmentation of arrow-like objects, and the extraction of image features from these objects. The authors then input these features into standard classifiers: artificial neural networks, evolving artificial neural networks, and evolving artificial neural network ensembles.

This brings us to the last segment of this volume, the emerging paradigms of healthcare IST innovations.

**EMERGING PARADIGMS OF HEALTHCARE IST INNOVATIONS**

Two papers were identified and included in this final segment about the emerging paradigms of healthcare IST innovations. These works include contributions from Rocha (2011) and Arling et al. (2011). The first contribution relates to the maturity model of healthcare ISTs whereas the second relates to the use of a social network approach to view improvements in evidence-based practice and healthcare IST implementation.

Rocha (2011) provided a review of the evolution of IST maturity models, including the early work of Nolan (1973; 1979), that of Galliers & Sutherland (1991), that of Sharma (2008), which is more specific to eHealth adoption, and a number of other IST maturity models (e.g., Priestman, 2007; Holland et al., 2008), which are more relevant and specific to understanding the diffusion of eHealth innovations. Evidently, the concept of IST maturity has long been advocated in the literature, but the variations among these models have to do with how many stages of growth or maturity levels may be envisioned and the particular domains for which the different models are best suited. For instance, Sharma’s Quintegra
Maturity Model proposes 7-stages of growth that are specific to eHealth adoption while the 7-stage HMISS Maturity Model applies well for EMR (electronic medical records). Similarly, the NHS (UK National Health Service) Maturity Model was developed for EPR (electronic patient records) and has 6 stages whereas the IDC (Health Industry Insights) Maturity Model has only 5 stages and is likely most applicable for IST implementation and growth in hospital settings.

The final contribution in this volume is the work of Arling et al. (2011). In this work, the social network analysis (SNA) perspective, a new perspective on analyzing how health IST innovations can transform the healthcare services delivery system, is being advocated. More specifically, the context of the research in which this perspective has been grounded upon relates to investigating provider practice in the use of health IST (i.e., the evidence-based practice (EPB) implementation) to reduce risk of MRSA (Staphylococcus aureus) and for monitoring and tracking the spread of methicillin-resistant in an infectious disease program, the MRSA project. Apparently, this contribution will aid both healthcare researchers and practitioners seeking a new paradigm for understanding the influence of health IST innovations such as the implementation of a EPB-relation information system along a socially-oriented perspective.

REFERENCES


