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Innovation in Healthcare: Harnessing New Technologies

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Innovation in Healthcare: Harnessing New Technologies

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Abstract

This article provides a health information technology practitioner's perspective on how the healthcare industry is harnessing emerging technology for research, discovery, and enhanced healthcare delivery. It draws conclusions and insights regarding the balance between innovation and investment in IT with reduced budgets and the uncertainties of the healthcare regulatory environment. Four specific case studies are briefly summarized of innovative applications introduced to improve healthcare delivery. The case studies include 1) Electronic Health Record (EHR) Early Sepsis Patient Identification and Alert System, 2) Bed, Patient Flow, and Transportation Management, 3) a Telehealth Initiative, and 4) a Mobile Stroke Unit. The final section briefly discusses and proposes relevant research questions that should be addressed.

Keywords: health information technology (HIT), electronic health record (EHR), innovation, emerging technology, Internet of Things (IoT), mobility, cloud-based computerized clinical decision support (CDS) system

"This article presents the view and opinion of its author and does not represent the position of the JMWAIS Editorial Board or the position of Methodist Le Bonheur Healthcare."

1. Introduction

The objective of this article is to examine the following four broad topic areas from the perspective of a healthcare information technology (HIT) practitioner:

- Review of healthcare IT emerging trends.
- Explore concepts around how the healthcare industry is harnessing emerging technology for research, discovery and enhanced healthcare delivery.
- Review strategies on achieving the appropriate balance between innovation and IT investments given fiscal and regulatory environment constraints.
- Highlight several case studies on the use of innovative applications or disruptive technologies for improved healthcare delivery.

2. Background

According to the Centers for Medicare and Medicaid Services (CMS), the healthcare industry is the fastest growing industry in the United States with expenditures estimated at $3.4 trillion in 2016, up 4.8% from 2015. Furthermore, the national health spending is projected to grow at an average rate of 5.6% per year for 2016-25, and 4.7% per year on a per capita basis (CMS, 2017). By 2025, health care expenditures are predicted to account for more than 20% of the nation's GDP and will become the single largest national expenditure at $5.5 trillion. Healthcare growth factors in the U.S. include an aging population, increased lifespan, and growing costs associated with providing health care.

The adoption of healthcare information technology (HIT) has been slow and inconsistent as compared to other industries. HIT utilization has primarily been spurred by government incentives, most recently the by the Health Information Technology for Economic and Clinical Health Act (HITECH) which was enacted as part of the American Recovery and Reinvestment Act (ARRA) of 2009 (U.S. Department of Health and Human Services, 2017).

Through these measures federal stimulus money has been made available for implementation of electronic health record (EHR) systems, online quality reporting, and other technologies. However, it is quite disappointing that while the public generally marvels at the scope and pace of innovation in high-profile medical technologies, there is less praise about innovation in basic clinical, business, and patient care delivery processes. In the U.S. we have arguably taken the latest medical technologies of the 21st century and embed them within a service delivery and patient flow process that has remained fundamentally unchanged since the 1950s — complete with patient provider interactions occurring in a classic brick and mortar facility. Some researchers have posited the notion that innovation in healthcare is not a complicated issue but rather a complex issue (Plsek, 2003). The fact that the healthcare industry lags behind as compared to other industries is further confirmation of this complexity (Kandel, 2016).

3. Visioning the Future of Healthcare Delivery

There is growing evidence of a healthcare delivery model paradigm shift. The future of healthcare delivery from the perspective of the consumer is truly a ubiquitous patient to provider interaction. The three pillars of "care anywhere, care networking and care customization" have emerged as central to the argument for a personal health consumerism model (Dishman, 2013). Dishman (2013), who served as a former healthcare strategy group leader for Intel Corporation, eloquently portrays our U.S. healthcare system as flawed and expensive. While there is arguably progress being made throughout the nation, there are still significant goals to accomplish for the benefit of patients and care givers. Dishman (2013) contends that an alarming percentage of medical errors are related to communication breakdowns amongst members or care teams such as specialists, nurses, allied health providers and primary care providers – each assigned for each problem or body part, trial and error drug use, and passive patients. Dishman's

(2013) challenge to the healthcare industry is to adopt new technologies such as big data, machine learning, and predictive analytics for the benefit of each individual patient under the supervision and care of a multidisciplinary team of care givers. This is just one compelling vision of a future state personalized health system.

According to Omachonu and Einspruch (2010), the healthcare industry has experienced a propagation of innovations aimed at enhancing quality of life, diagnostic and treatment options, in addition to the efficiency and cost effectiveness of the healthcare system. The adoption of information technology has undeniably played a critical role in the innovation of healthcare systems. The areas of disruptive technologies often refer to innovations that disrupt existing legacy systems, create new players or solutions, and deliver remarkable value to stakeholders upon adoption. Figure 1 illustrates a conceptual framework for innovation in healthcare in which organizations serve six very unique ideologies : treatment, diagnosis, prevention, education, research, and outreach (Omachonu and Einspruch, 2010). The authors suggest that the most successful healthcare innovation initiatives focuses on access to care by the patient; ability to meet the expectations of the patient relative to how care is provided; ability for the patient to address concerns to the care team and how a patient's care needs are delivered by the provider.

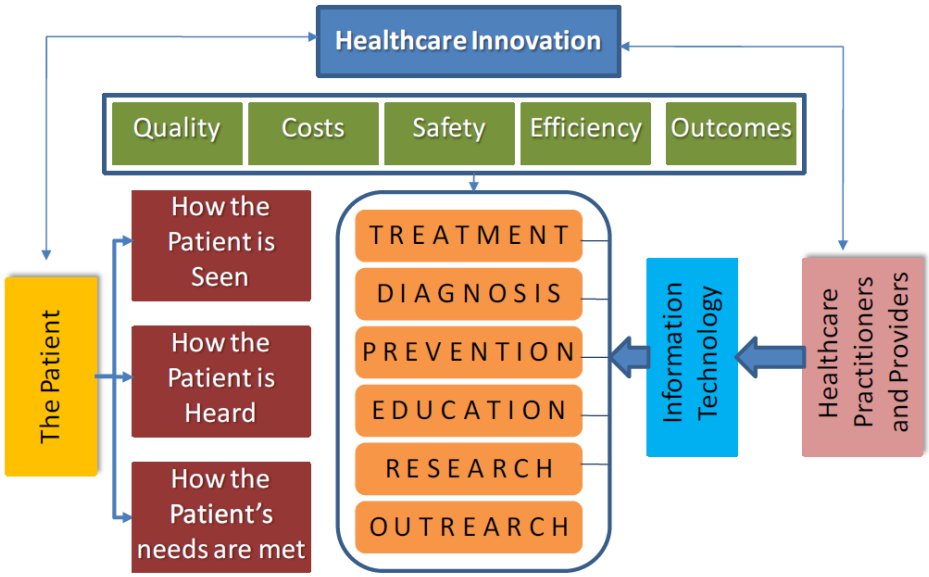

Figure 1. Conceptual Framework for Innovation in Healthcare (Omachonu and Einspruch, 2010)

The complexity of healthcare innovation and adoption of disruptive technologies is evident when one factors in environmental and operational dimensions such as: organizational leadership, culture, regulatory acceptance, physician adoption, partnerships, collaboration, patient satisfaction, profitability, efficiency, patient safety, cost containment, clinical outcomes and quality (Varkey, Horney, & Bennet, 2008).

Scientific advances in areas such as genomics, proteomics, and bioinformatics are now creating possibilities of tailoring medicine, nutrition and disease prevention to the individual – commonly referred to as *precision medicine*. This development combined with emerging technologies like synthetic biology and nanotechnology, are laying the foundation for a revolution in healthcare and well-being that will be less resource intensive and more targeted to individual needs. (Mimezami, Nicholson, & Darzi, 2012).

4. Healthcare IT Industry Trends

The federal incentive programs (commonly referred to as "meaningful use") were created by the 2009 economic stimulus package in an effort to improve patient care and electronic health records (EHRs) adoption. As a result, the Healthcare Information Systems Society (HIMSS) developed an analytics framework depicted in Figure 2 to quantify the level of adoption by healthcare institutions called the Electronic Medical Record Adoption Model (EMRAM). This eight stage model quantifies the adoption level and utilization of EMR functions through a methodology and algorithm developed by the HIMSS Analytics group (HIMSS Analytics, 2017). The published literature often examines the relationship among EHR adoption stage and hospitalized patients' satisfaction and adverse outcomes (Fletcher, et al., 2015).

HIMSS EMR Adoption Stage	EMR Adoption Model (EMRAM) Cumulative Capabilities
7	Complete EMR, Data Analytics to improve patient care; Continuity of Care Documentation transactions to share data; data continuity with Emergency Department, ambulatory and outpatient venues of care.
6	Physician Documentation (structured templates), Full Clinical Decision Support System, Closed Loop Medication Administration
5	Full Radiology Picture Archiving Communication System (PACS)
4	Computerized Physician Order Entry (CPOE); Clinical Decision Support (clinical protocols)
3	Nursing/clinical documentation (flow sheets); Clinical Decision Support System (error checking); PACS available outside of Radiology
2	Clinical Data Repository (CDR), Controlled Medical Vocabulary, Clinical Decision Support, may have document imaging; health information exchange (HIE) capable
1	Ancillary computer systems installed: Laboratory, Radiology and Pharmacy
0	All three ancillary computer systems not installed

Figure 2. HIMSS Analytics EMR Adoption Model (adapted from HIMSS Analytics, 2017)

This body of research seems to reach consensus that advanced stages of EHR adoption show some promise in improving important patient care outcomes such as preventing prolonged length of stay and frequent hospital readmissions. The overall journey to improve patient care and electronic health records (EHRs) adoption is illustrated in Figure 3. Stage 1 consists of basic data capture and sharing among healthcare providers. This level includes capturing health information in a standardized format; tracking key clinical conditions; communication of information for care coordination processes; reporting of clinical quality measures and public health information; patient and family engagement. Stage 2 consists of advanced clinical processes. This level includes a more rigorous health information exchange (HIE); improved patient care through clinical decision support, care coordination and patient engagement; the electronic transmission of patient care summaries; and more patient-controlled data. Stage 3 consists of improved patient outcomes. This final level includes improving overall quality, patient safety, and efficiency; decision support for national high-priority patient conditions; patient access to self-management tools; access to comprehensive patient level data through patient-centered HIEs; and improved overall population health. As discussed by Burwell (2015), the U.S. Department of Health and Human Services (HHS) purposefully devoted programmatic resources on augmenting healthcare reform in three very symbiotic ways: (1) incentives to motivate higher value care by linking payments through alternative provider payment models; (2) changing the way care is delivered through increased care delivery teamwork/integration; and (3) increased attention to population health as a way to improve care for patients.

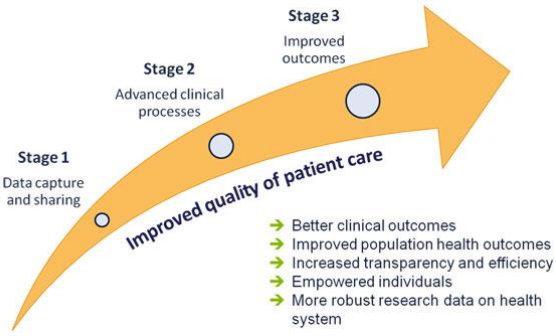

Figure 3. Meaningful Use Stages (eHealthDC, 2017)

The concept of innovation was defined by Senge (2010) as the widespread adoption of new technology and ideas. He also described systems thinking as the foundation of learning organizations, and organizational learning as the cornerstone of innovation. Navigating the uncertainty of healthcare and increased adoption of technologies arguably requires systems thinking. As a matter of fact, the prominent Baldridge healthcare criterion for performance excellence represents a very applicable framework for this systems perspective as depicted in Figure 4. The concept as applied to healthcare technology adoption would lend itself to leverage this leadership and performance management framework to enable an organization, through technology adoption, to accomplish its mission, improve results, and become more competitive (NIST, 2017).

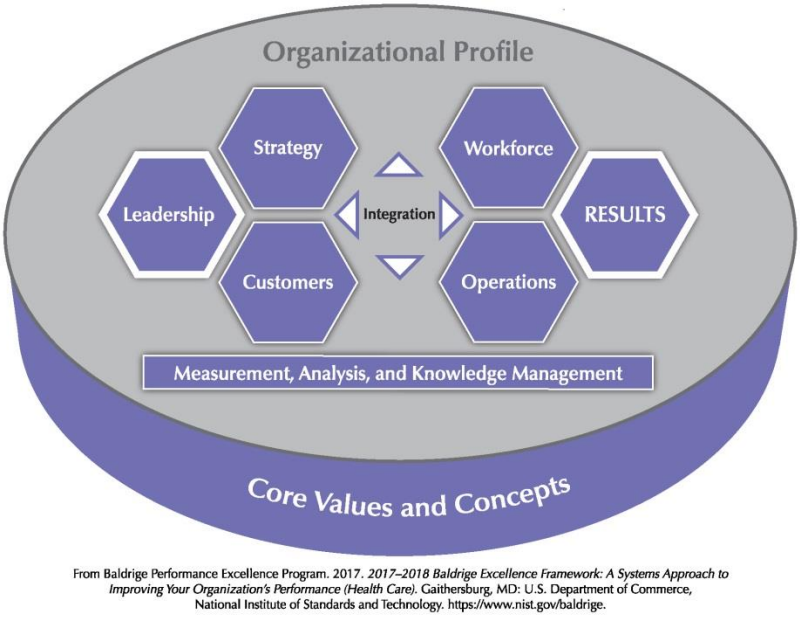

Figure 4. 2017-2018 Baldridge Excellence Framework (NIST, 2017)

According to Adams (2017), four common healthcare organizational imperatives have emerged in the post Obama-Care era: improvement and expansion of access to care; provision of high value and affordable services; clinical, service quality and reliability improvements; and attainment of customer loyalty. These strategic priorities in turn have challenged health care organizations to leverage IT solutions for enabling coordination and integrated care along with addressing these consumer-driven healthcare needs.

The net impact to healthcare leaders is a list of ten major IT-related issues based upon a survey of The Health Care Advisory Board Company membership (an independent strategic research division of the Advisory Board company founded in Washington, D.C. circa 1979). This listing of 2017 health IT top ten issues is summarized in Table 1 (Adams, 2017).

• Quality Reporting • EMR Optimization • Analytics and Business Intelligence • Interoperability • Population Health Management	• Consumer-Focused Healthcare • Telemedicine • Digital Health Systems • IT Performance and Risk Management • Information Security

Table 1. Healthcare IT top ten issues in post-Obama Care era (Adams, 2017)

This listing of issues is relevant for today's healthcare leaders and information systems solutions. As evident by this broad spectrum, these strategic priorities cover people, processes, and technological issues.

Machine learning is yet another factor impacting future health IT trends. As acknowledged by Dydra (2017), the field of artificial intelligence (AI) and its application, commonly referred to as machine learning (ML), represent immense possibilities in the healthcare industry. More specifically, machine learning has tremendous potential to improve medical diagnostics, patient care pathways, and surgical procedures - contributing to overall improved patient clinical outcomes. The expansion of artificial intelligence use cases and the growth in wearable devices in healthcare will greatly influence patient care decision making. This emergence of FDA approved wearable devices and healthcare specific sensors or monitors are yet another example of these disruptive technologies collecting massive amounts of passive data. The research firm IDC estimates the exponential projected growth rate of health data to over 2,000 exabytes by the year 2020 (Corbin, 2014). This factor, not only has an impact on patients and providers, but is requiring innovative thinking around the incorporation of cloud technologies and cyber security considerations. As postulated by Xu, He, & Li (2014), the proliferation of mobility applications and Internet of Things (IoT), such as the increasing ubiquity of RFID, wireless devices, and sensor devices is also a challenge or opportunity for many U.S. healthcare institutions.

5. Innovation Case Study Synopsis: Methodist Le Bonheur Healthcare

Methodist Le Bonheur Healthcare (MLH) is an integrated health care delivery system based in Memphis, Tennessee. Founded in 1918 by The United Methodist Church to help meet the growing needs for quality health care in the Mid-South, Methodist has grown from one hospital into a six-hospital system that includes Le Bonheur Children's Hospital, a national US News and World Report Best Children's Hospital. MLH also offers a home health agency, ambulatory surgery centers, outpatient facilities, hospice residence and physician practices serving all corners of the Memphis and Mid-South community. For six consecutive years, Methodist has been named the best hospital in Memphis by U.S. News and World Report. Great Place to Work® and Fortune ranked Methodist Le Bonheur Healthcare on its 2017 100 Best Companies to Work For, #21 for 2016 Best Workplaces for Diversity, and #1 on the 2016 list of Best Workplaces for African Americans. With more than 13,000 associates and 1,650 licensed beds, MLH provides care for over 60,000 inpatient admissions annually (MLH, 2017). Methodist Le Bonheur Healthcare was named as a *2017 Most Wired Hospital*, according to results of the 19th Annual Health Care's Most Wired® survey, released by the American Hospital Association's (AHA) Health Forum. According to this survey, Most Wired hospitals are using smart phones, telehealth and remote monitoring to create more ways for patients to access health care services and capture health information. In addition, Most Wired hospitals, such as MLH, are transforming care delivery with knowledge gained

from data and analytics. They are investing in analytics to support new delivery models and effective decision-making and training clinicians on how to use analytics to improve quality, provide access and control costs.

The case studies depicted in Table 2 are indicative of four specific scenarios where innovative approaches to the implementation of information technology solutions were used to solve a range of business/clinical problems.

Table 2. Healthcare IT Innovation Case Studies

Case Study	Title	Background	Technology Solutions	Outcomes
# 1	**Electronic Health Record (EHR)[1] Early Sepsis Patient Identification and Alert System**	• Sepsis is a potentially life-threatening complication of an infection. Sepsis occurs when chemicals released into the bloodstream to fight the infection trigger inflammatory responses throughout the body. This inflammation can trigger a cascade of changes that can damage multiple organ systems, causing them to fail. • If sepsis progresses to septic shock, blood pressure drops dramatically, which may lead to death. • Early detection is critical to early intervention.	+ 2007 initiative with EHR vendor and internal staff to develop and refine an early sepsis algorithm within the EHR. + Development and testing of an auto alert messaging system with nursing and medical staff. + Sepsis auto alert messaging to iPhone, tablet, or Apple watch. + Sepsis Coordinators at each hospital can remotely monitor their sepsis patients very quickly through these devices.	Decrease in baseline sepsis incident rate of 24.5% in 2006 to the 2016 rate of 14% translates to about 49 patients every single month who now survive their sepsis to celebrate another birthday with loved ones.
# 2	**Bed, Patient Flow, and Transportation Management**	• Challenges identified by inefficient patient bed management, patient flow during admissions process, and transportation of patients to/from diagnostic testing areas. • Current state involved a legacy bed tracking system, resource intense communication workflows.	+ Implementation of real-time dashboard and communications mobile iOS app developed with API integration into EHR. + Agile design using JavaScript, HTML and CSS on front end; back end using PHP and NodeJS; MongoDB and Microsoft SQL; hardware and software virtualized using containerization.	+ Improved efficiency and effectiveness of patient flow and bed management. + Improved communication among care teams. Note: Impact to Length of Stay (LOS) data and Patient Satisfaction

[1] The MLH EHR vendor referenced in this case study is *Cerner Corporation* (https://www.cerner.com/)

				scores pending data collection and reporting.
# 3	**Telehealth Initiative**	Telehealth program goals included: • Enable Service Line Extensions • International Nephrology Consults • Patient-to-Provider Televisits • Provider-to-Provider Televisits	+ Vidyo® Telemedicine Video Conferencing Software and Networking Hardware. + Vidyo® Solution was a balance of Cost and Value + Vidyo® willing to customize a virtual waiting room with prescribable educational content.	Over 75 successful Televisits completed with just-in-time physician specialist intervention and positive patient outcomes (2016 YTD data)
# 4	**Mobile Stroke Unit**	• People in Shelby County suffer strokes 37 percent more often than the national average. • The Mobile Stroke Unit in Memphis is the first launched in the high-incidence Southeastern United States "Stroke Belt".	+ Capable of conducting and producing advanced quality imaging for stroke diagnosis and noninvasive CT-angiography. + IT solutions: LifeIMAGE® medical image sharing and wireless telecommunications infrastructure to interface with EHR .	+ The University of Tennessee College of Medicine Launched the World's First Mobile Stroke Unit with Advanced CT Imaging Capabilities Including CT Angiography Imaging for the Brain and Blood Vessels. + In the first four months of 2016 operations, they have responded to 187 calls and transported 91 patients (17 received tPA to treat blood clotting in the brain).

5.1 Electronic Health Record (EHR) Early Sepsis Patient Identification and Alert System

In this Clinical Decision Support (CDS) case study, MLH medical and IT staff engaged its enterprise EHR system (Millenium: Cerner Corporation, Kansas City, MO) to implement a clinical algorithm and automated clinical messaging alert system for early detection of sepsis conditions. This Cerner solution branded as the St. John Sepsis Surveillance Agent®, leverages published evidence-based medicine treatment guidelines and uses cloud computing with big data analytics to complete the patient screening process. The EHR then alerts on high-risk patients early in their infectious process, while increasing precision in estimating mortality risk enabling medical decision support. Given that Sepsis results in a high in-patient mortality rate, this early detection was deemed critical to early treatment of patient's diagnosed with this life-threatening condition in which the body is fighting a severe infection that has spread via the bloodstream. The outcomes of this innovative approach to sepsis treatment included a marked decrease in the baseline sepsis incident rate of 24.5% in 2006 to the 2016 rate of 14%. This translates to about 49 patients every single month who now survive their sepsis diagnosis to celebrate another birthday with loved ones. According to Amland and Hahn-Cover (2014), the clinical literature supports the theory that such a cloud-based sepsis CDS integrated with enterprise-wide EHR systems is indeed an effective approach toward early recognition of sepsis in a hospital setting.

5.2 Bed, Patient Flow, and Transportation Management

This case study involved the collaboration of multiple MLH departments in an effort to improve upon known inefficient patient flow and bed management processes highlighted during the patient admissions process. In addition, the innovative approach was also applied to the transportation of patients to and from diagnostic testing areas. This solution required a dedicated team from the MLH process improvement, innovation and analytics department working in conjunction with clinical leaders and IT support staff. The innovation development team applied agile development techniques to implement a mobile based solution which integrates seamlessly with the EHR. This also includes the availability of real-time patient dashboards to improve throughput and communication. Although in the relatively early stages of an enterprise-wide deployment, MLH has seen an improved efficiency and effectiveness of patient flow, bed management process and overall improved communication among nursing, transportation and environmental care delivery teams.

5.3 Telehealth Initiative

Under the auspices of medical staff and executive leadership, MLH embarked upon a Telehealth program initiative with four specific goals: to enable medical service line extensions; enable international nephrology specialty consultations; enable patient-to-provider Televisits; and enable provider-to-provider Televisits. This included project planning and implementation of commercially available video conferencing software, networking hardware and telecommunications. MLH is now considering the expansion of this program given the level of success as measured by successful Televisits completed with just-in-time physician specialist intervention and positive pediatric patient outcomes.

5.4 Mobile Stroke Unit

This case study involves the implementation of medical technology via a mobile stroke unit model. The outcome is saving patient lives by a decrease in the amount of time required to treat stroke patients in the city of Memphis. In collaboration with MLH, the University of Tennessee Health Science Center launched this initiative with a 14-ton ambulance as part of a three-year controlled study. The mobile stroke unit has a CT scanner that can take radiological images of the brain, and is equipped to provide early fluids to stroke patients and dye blood vessels to determine the type of stroke the patient has encountered. This sophisticated stroke treatment center on wheels has transported 171 patients and has administered 35 treatments of a drug called alteplase, commonly referred to as tPA, which is a clot-busting

medicine (Peterkin, 2017). This three-year trial program is being conducted to convince programs like Medicare and other third-party insurance payers that the mobile stroke unit is a safe and efficient way of transporting stroke patients.

This Memphis stroke unit team case study is projected to have the data required after successfully treating 300 patients over the course of the three-year trial. Ultimately, the patient benefits tremendously with rapid intervention since it takes on average about 40 to 50 minutes to treat stroke patients during a typical emergency room visit as compared to the average 13 to 14 minutes for the same treatment protocol administered on this mobile stroke unit (Peterkin, 2017).

6. Recommendations for Future Research

Healthcare services are changing in many ways including more effective and efficient use of information technology and electronic health record to improve patient care. It is evident that the U.S. healthcare organizations are inherently complex and will continue to focus on strategic priorities by implementing enabling information technology solutions. The potential for significant research contributions in this area currently exist. Specifically, the following are some areas of healthcare IT innovations that should be considered for future research:

a. What innovative applications have resulted in improved healthcare delivery?
b. How does leadership foster a culture of innovation in the disciplined and regulated arena of healthcare delivery?
c. How do building and sustaining innovation teams impact the development and efficacy of healthcare application solutions?
d. How can organizations balance innovation and investments in healthcare IT with reduced budgets and the factors surrounding such a highly regulatory environment?
e. Is there a correlation between successful healthcare organizations and the implementation of innovative methodologies and technologies?

7. Conclusion

The existing healthcare IT literature and outcomes documented in the four concrete case studies discussed in this article appear to support the thesis that an innovative approach to the adoption of disruptive technologies can add value to the complex environment of the healthcare industry. The case studies support the notion that harnessing emerging technologies for research, discovery, and enhanced healthcare delivery is possible and potentially can significantly improve healthcare delivery and services. Given that many healthcare delivery organizations are facing budgetary constraints as well as a uncertain regulatory environments or market changes, the need for innovation and new technology adoption is paramount.

It is even more apparent that in order to improve upon the patient experience, absent a radical redesign of the healthcare delivery model, healthcare leaders and IT professionals should adhere to the broad spectrum of business process management by incorporating people, processes, and emerging technology in their day-to-day operations. Conway, Coyle, and Sonnefeld (2017) remind us of the importance of leadership, systems thinking, and alignment as a foundational element towards promoting patient safety innovation.

The ability to adapt to the top issues impacting healthcare IT organizations in the post-Obama Care era will remain a critical success factor. These risks and opportunities can possibly be mitigated by a systems thinking approach to accomplish the desired outcomes while supporting the mission of serving patients and their families.

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