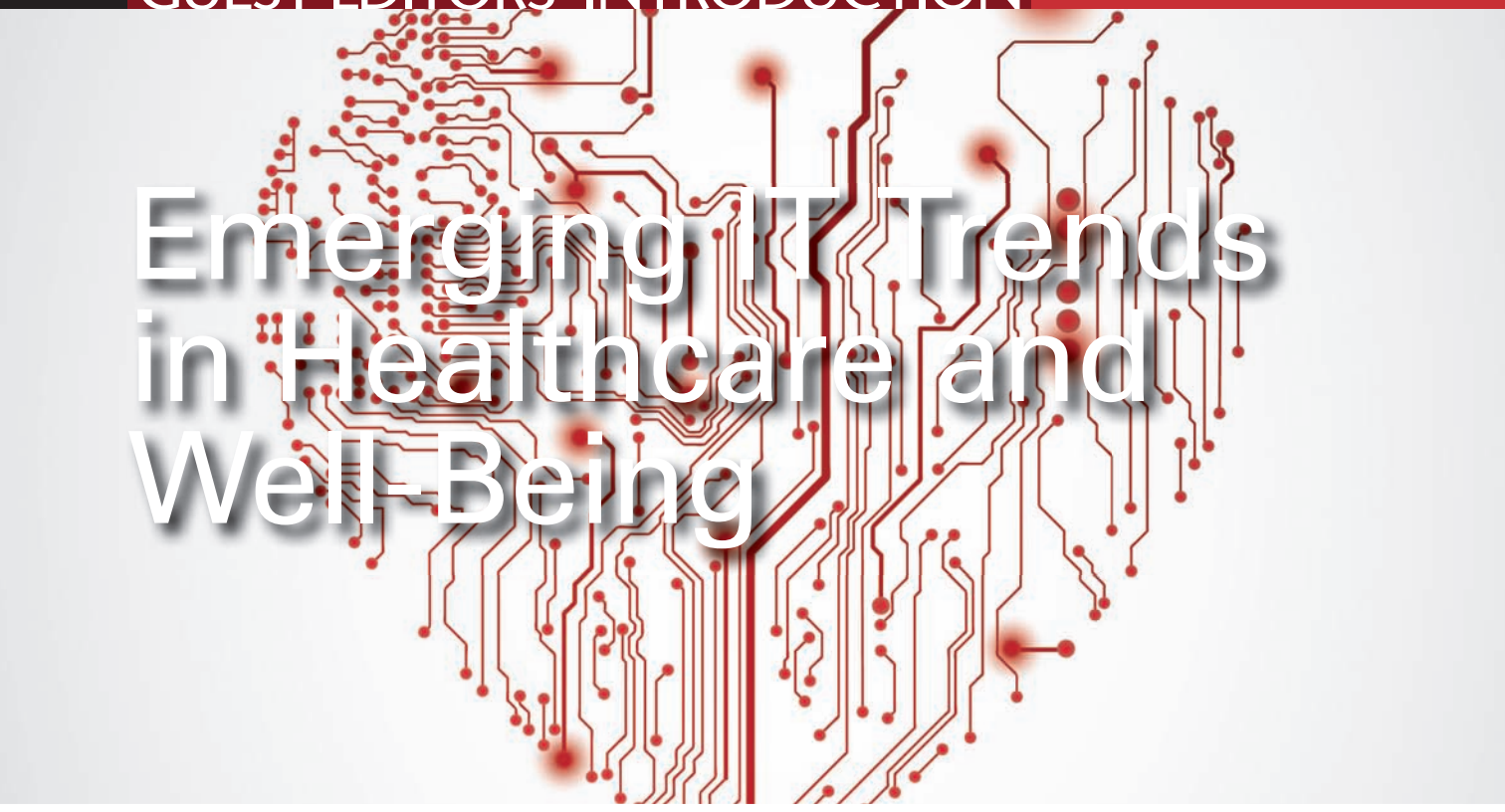

Emerging IT Trends in Healthcare and Well-Being

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The importance of IT in healthcare continues to grow, driven by disruptive changes, including the financial pressure health systems face combined with an aging population; the spread of connectivity and mobile technology; and significant advances in the biology of disease and the practice of medicine. All demand or lead to new advances in health IT (HIT).

In North America, spending on healthcare is growing faster than the national income.[1] The unsustainable growth of health costs alone has forced governments and the healthcare industry to explore new ideas for healthcare delivery. HIT has been identified as a way of reforming and improving the efficiency, cost-effectiveness, quality, and safety of medical care delivery in the healthcare system.[2] In addition, the abundance of data evidence drives improvements in care quality by preventing errors and increasing efficiencies through a reduced need for expensive interventions (such as laboratory tests or diagnostic imaging), emergency room visits, hospitalizations, and adverse event discovery and procedures. Lastly, HIT is utilized to support team-based collaborative care delivery that bridges providers and settings.[3]

Additional HIT technologies that drive healthcare transformation include electronic medical record technologies (EMR/EHR) and health information exchanges (HIEs); pervasive software delivery models that utilize cloud, wearable, and smart appliance computing; data technologies ranging from clinical decision support to clinical business intelligence and predictive analytics; technologies promoting patient engagement, self-care, and use of social media; (remote) patient monitoring using home or wearable devices; and the emergence of clinical genomics and personalized medicine.

The presence of such technologies creates tectonic changes in the healthcare system, which is not only about healing the sick. Rather, the focus is shifting to prediction, prevention, and

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promotion of human health, patient outcomes, and healthy living. Growth in technology has also increased the demand for HIT professionals, which is expected to rise by 22 percent by 2020 (www.bls.gov/oes/current/oes292071.htm). This demand has led many academic institutions to create new degrees and programs to prepare students to join this fast-growing profession.

Many barriers and challenges are associated with integrating HIT into the healthcare fabric, including the need for interoperability and information exchange between health information systems and devices, and the safety and security of individual patient records in a digital world. Balancing patient privacy protections with advancing systems interoperability and enabling more data-driven analytics is an ongoing challenge for many healthcare organizations. With these barriers and challenges in mind, we are witnessing increased willingness in healthcare systems to use technology, with more emphasis on meaningful use of HIT (https://www.healthit.gov/policy-researchers-implementers/interoperability) and the promotion of interoperable technologies that span the entire care continuum. We highlight some of the game-changing HIT technologies we anticipate being the focus of attention in the research and practitioner communities in the coming years.

Patient Engagement and Patient-Generated Data

Over the past decade, we have seen a tremendous shift toward more direct, active engagement of patients in their healthcare.[4] Networked consumer health devices such as fitness trackers, blood pressure monitors, heart rate sensors, and weight scales are increasingly popular, supported by a growing market of mobile apps serving a wide range of functions related to health and well-being. Patient-generated data are aggregated in consumer-focused health information systems, commonly referred to as personal health record (PHR) systems.[5] Newer PHRs are specifically targeting particular consumer healthcare needs, such as chronic disease management and fitness. Such systems have been shown to be effective in improving patient health and engagement, even without the presence of direct information flow to clinical systems.[6] Healthcare providers are beginning to explore patient-generated data in clinical systems and formal care processes. This includes not only device-generated measurements but also patient-reported outcome data collected by electronic surveys. Integrating patient-generated data into formal care processes poses technical as well as regulatory challenges that are subject to active research in the health informatics domain.[7] These challenges include questions about the reliability of patient-generated data and the advice generated by consumer health apps. They also include questions about informational privacy and use of patient-generated data.

Mobile Technology in Healthcare

Mobile health, or *m-health,* refers to the generation, aggregation, and dissemination of health information via mobile and wireless devices and the sharing of that information between patients and providers. A recent HIMSS survey documents the interest among healthcare organizations in deploying mobile technologies with the aim of engaging patients (http://www.himss.org/2015-mobile-survey). Similarly, a literature review explored the proliferation of smartphone articles in health research between 2002 and 2012,[8] showing a clear upsurge between 2007 and 2008, when the number of articles almost doubled. The review showed growing research interest in the area of m-health, together with an increased complexity in research designs and aim specifications, as well as a diversification of impact areas. A plethora of m-health applications that are already in use range from diabetes mobile monitors, to smart medication bottles, to mobile imaging devices, to generic remote monitoring mobile devices. In the broader healthy lifestyle market, a new range of wearable self-monitoring devices (such as pedometers and calorie counters) are contributing to prevention and health promotion.

Electronic Medical Records and Health Information Exchanges

The current healthcare delivery paradigm involves multiple health services partners that continuously connect and exchange information. The need for connectivity is paramount. EMRs and HIEs contribute significantly to the design of connected healthcare delivery. Coordination in healthcare delivery is important in chronic disease management and continuity of care. However, this coordination is hindered by the

poor information exchange capabilities of existing health information system architectures. A fundamental focus of HIT research is to bring forward new ideas for interoperability and information exchange in the design and implementation of EMRs and HIEs that actively facilitate collaboration in different contexts, such as between acute care settings and primary care settings in the community. Facilitating collaborative care delivery requires tracking the various members of a patient's care team and coordinating care delivery across the team (www.ncbi.nlm.nih.gov/pubmed/21576534).

Contemporary EMR and HIE designs for collaborative care delivery are concerned with the broad design objectives of improving collaborative team-based care delivery, enabling the development of collaborative healthcare processes, and achieving people and process interoperability.[9]

Clinical Decision Support and Data Analytics

Most of the inefficiencies and opportunities for improvement in an organization are hiding in its data. Similarly, data evidence is essential for clinical decision making. The increased use of EMRs eases data collection, but simultaneously makes the use of data evidence more challenging due to the volume, variety, veracity, and velocity (speed) of available data—that is, there is more data, but less time to make decisions. This problem is proverbially named the *big data problem* of modern healthcare, which technical advances in business intelligence and data analytics are aspiring to solve. A variant of clinical data analytics is known as clinical decision support (CDS), where information, usually at the point of care, is used to inform decisions about a patient's care. A recent HIMSS survey demonstrates the growing attention of healthcare organizations in CDS to goals that include error reduction, increases in efficiency, and help in enforcing standardization and cost reduction. CDS is a prominent research area that involves methodologies and algorithms from diverse fields, including computing, artificial intelligence, and data science. More recent work describes a clear need for CDS systems for analyzing unstructured data, such as the clinical narratives found in EMRs.[10] There are many powerful analytic tools that utilize various kinds of big data in healthcare to help clinicians make more personalized, evidenced-based decisions. Such resources can extract relevant information and provide insights that clinicians can use to make evidence-supported decisions.

Genomic Medicine

Genomic medicine is an emerging discipline that involves the use of genomic information to make diagnostic or therapy decisions in patient care. Genomic medicine is a result of significant scientific advances in the past three decades in genome sequencing, the biology of disease, and computing. The transformative nature of genomic medicine in patient care is in its early days. Its path forward is linked to challenges and advances in HIT that span areas such as the integration of genomic information in EHRs, computational and algorithmic aspects of disease diagnosis, business applications of healthcare delivery (e-commerce websites providing health services versus traditional health service venues), clinician education, medical ethics, and patient privacy protection.

In This Issue

The articles for this special issue of *IT Professional* were selected through a rigorous review process and cover topics identified as emerging trends in HIT.

In "A Context-Aware, Interactive M-Health System for Diabetics," Shih-Hao Chang, Rui-Dong Chiang, Shih-Jung Wu, and Wei-Ting Chang present a context-aware interactive m-health system that provides real-time, two-way communication between diabetes patients and caregivers by utilizing Internet of Things (IoT) technology. This article is an example of the use of mobile communication medical devices by patients to engage in their own health in a chronic disease management scenario.

"M-Health Solutions Using 5G Networks and M2M Communications," by Willian D. de Mattos and Paulo R.L. Gondim, presents recent research linking the application of m-health to the need for 5G and machine-to-machine (M2M) technologies. The authors explore the benefits that these emerging network technologies should bring to enable the broad expansion of m-health solutions.

In the third article, "Emerging IT for Medication Adherence," Gregory Gimpel, Upkar Varshney, and Punit Ahluwalia present a roadmap for

how emerging IT can play a major role in improving medication adherence through the use of five major technologies: smartphone apps, smart medication boxes, smart pills, sensors, and implantable devices. This article touches on challenges arising from developing interoperable standards, security, and stakeholder collaboration.

In "Security in Cloud-Computing-Based Mobile Health," Silas L. Albuquerque and Paulo R.L. Gondim sample problems associated with the security of healthcare information stored in cloud environments and explore possible solutions. This article offers a balanced discussion of the positive aspects of cloud computing and m-health in healthcare with the risks arising from the adoption of these new technologies.

As patients are expected to participate in managing their own health, they become consumers of health information in text. In "Moving Beyond Readability Metrics for Health-Related Text Simplification," David Kauchak and Gondy Leroy tackle the problem of medical text comprehension and text simplification and present two contributions. The first is a strategy for designing effective text-simplification software, and the second is a new study examining existing readability formulas, which are the most commonly used tools for text simplification in healthcare.

In this special issue on emerging trends in HIT, we are also thankful to Eric J. Topol and Paddy Barrett for contributing a Spotlight perspective on their inspiring notion of *smartphone medicine*. In this invited article, these two physicians, digital health pioneers, and visionaries discuss the disruption that smartphones bring from everyday life to the fields of healthcare and medicine and explore the ways in which smartphones and the Internet of medical things can improve medicine both today and in the future.

Finally, this issue's Trends department discusses the IoT in healthcare—both potential applications and the challenges this technology presents.

The future of HIT can only be described as promising, as it undergoes changes that favor connected health, patient empowerment, increased availability of open linked data, more powerful HIT tools and applications, personalized medicine, higher security and privacy, and context awareness, with the ability to work with unstructured data and greater standardization of electronic health records moving toward meaningful use and ubiquity. All these developments will open up a world of possibilities for policy makers, the health industry, patients, and clinicians for better health and well-being. IT

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