Mobile Health Means Better Health Care for All

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Abstract— **Electronic health (eHealth) is an essential tool for improving healthcare delivery and patient care. Although the healthcare industry is information-intensive, it suffers from a high degree of fragmentation which results in inefficiency. There are four key steps in fixing this inefficiency.**

First, the healthcare industry should adopt Information and Communication Technology (ICT) systems that can allow effective health information management. When used effectively, health ICT systems, such as Electronic Health Record (EHR), Electronic Medical Record (EMR), and Personal Health Record (PHR) can significantly improve health information sharing and patient care.

Second, as patients are viewed as partners and participants in their care, PHR systems can enhance the healthcare delivery by engaging patients in their care process. Also, with today's increase of health consumerism, patients want to influence decisions about their care. The integration of PHR and EHR systems is critical to facilitate physician-patient partnership.

Third, for EHR, EMR, and PHR systems to create efficiencies and improve healthcare delivery, they should provide healthcare providers and patients with uninterrupted services and timely access to patients' records. The need for timely and around-the-clock access to patients' records calls for a seamless and secure cross platform to support a broad range of handheld devices used by healthcare providers and patients. Also, distance-irrelevant and mobile connectivity systems are required to ensure the availability of health information anywhere at any time.

Fourth, to further improve healthcare delivery, mobile technologies should support eHealth. This practice is referred to as mobile health. Mobile health (mHealth) includes the use of a mobile phone's simple utilities, such as voice and short messaging services. It also includes more advanced functionalities and applications, such as space-based satellite navigation systems, smart phones, and Bluetooth technologies.

Most of computer-related security risks are valid for mobile technologies. When used properly, however, security risks associated with the use of mobile technologies are lower than those of other technologies. The use of mobile computing devices is increasing across the world. For this reason, mobile health can considerably improve healthcare delivery in terms of patients' access to care. Nevertheless, several obstacles to the adoption of mobile technologies in health care must be overcome.

Index Terms— **Electronic health, Electronic Health Record, mobile health, mobile technologies,**

I. INTRODUCTION

Electronic health is an essential tool for enhancing healthcare delivery and patient care. Although the healthcare industry is information-intensive, it experiences a high level of fragmentation that results in inefficiencies [1]. This article examines four steps deemed critical to fixing such inefficiencies. Information and communication technology (ICT) has undeniably revolutionized industries such as banking and aviation. ICT has empowered bank and airline customers to have access to a wide range of services irrespective of time and location.

ICT has not had the same impact on the healthcare industry. Although it is widely recognized that effective use of health ICT systems has the potential to improve the quality of healthcare delivery, the healthcare industry has been slow to adopt modern ICT systems. When implemented and used properly, health ICT systems can provide the healthcare industry with several benefits. These benefits include among others: 1) enhanced health information management, 2) timely access to patients' health records regardless of time and geography, 3) better communication between both healthcare providers and consumers, and 4) better use of scarce commodities such as available healthcare providers.

With the increase of health consumerism, individuals want to participate in, and influence decisions about, their own care. Also, as healthcare professionals prefer to view patients as partners in healthcare processes, improved communication between the two is essential for effective partnership. It has been recognized that the integration of electronic health record (EHR) systems and personal health record (PHR) systems has the potential to facilitate such partnership. PHR systems can increase patient's participation in health care and improve communication between individuals and their healthcare providers.

Furthermore, the healthcare industry experiences several challenges, like the shortage of healthcare providers, especially in high-demand specialties. Moreover, patient care increasingly requires an interdisciplinary teamwork approach involving healthcare professionals operating either locally or at distance. Working over long distances however, presents challenges for effective collaboration and information sharing.

Improving the quality of healthcare delivery depends on the degree of ICT systems adoption. A greater degree of adoption not only allows effective teamwork, but also connects dispersed healthcare stakeholders together. Thus, there is a need for ICT systems that can overcome time and distance. As distance-irrelevant technologies eliminate time and space

boundaries, patients can benefit in a timely manner from the expertise of healthcare providers across the globe.

For ICT to truly create efficiencies and improve healthcare delivery, it is imperative that all healthcare stakeholders have timely access to health information of relevance. For this reason, to further improve healthcare delivery, mobile technologies should support the use of electronic health. In other words, the need for timely and around-the-clock access to patients' records (and other relevant information) calls for a seamless and secure cross platform to support a broad range of handheld devices used by healthcare providers and patients.

A review of literature reveals that more than five billion people across the world use wireless devices and that the commercial wireless coverage represents over 85 percent of the world's population [2]. Thus, mobile health can considerably improve healthcare delivery in terms of health costs containment and patients' access to care by reaching populations in underserved regions. Notwithstanding, several obstacles to the adoption of mobile technologies must be overcome.

II. ELECTRONIC HEALTH AND HEALTHCARE DELIVERY

The quality of healthcare delivery depends on several factors such as health information sharing, effective collaboration, and relationship between patients and healthcare providers. These factors have a positive association with the quality of healthcare delivery and patient satisfaction. For this reason, patients should actively, and proactively, participate in their care process. To improve the quality of healthcare delivery, healthcare providers and healthcare consumers, also known as patients, should work collaboratively as equal partners.

Today healthcare providers are required to operate in a team-oriented environment to provide high quality care for patients. As patient care requires an interdisciplinary teamwork approach involving healthcare professionals operating either locally or across the globe, information management plays a significant role in the provision of health care. Successful delivery of health care in a team-oriented setting requires effective management of not only the patient and expenditure flows but also the critical health information flows.

To meet the increasing health needs of patients and the expectations of healthcare professionals, it is critical for electronic processes and communication to support the practice of health care. We refer to supporting health care in this fashion as electronic health (eHealth). The purpose of eHealth is to achieve the delivery of more efficient, safer, and higher quality care to healthcare consumers. Electronic health services include among others: 1) personal health records or personal health portals, 2) electronic medical records, 3) electronic health records, 4) medical smart cards, 5) telemedicine, 6) decision and knowledge support systems, 7) electronic prescribing systems, and 8) systems designed to automate administrative tasks.

These health ICT systems have the potential to revolutionize health care and enhance quality of health care. This is possible because they can engage patients in their care, improve health information sharing, and better the relationship between patient and healthcare provider.

Today, ICT has significantly changed the way information is collected, stored, shared, and used. With modern ICT systems, health information, knowledge, and expertise can be captured once and re-used several times when needed. By placing health information on integrated information systems, healthcare stakeholders can be provided with access to health information anytime and anywhere through pervasive computing technologies. ICT has the potential to make patient information available to multiple healthcare providers in real-time, throughout and outside the hospital, through the use of wireless tablet personal computers or handheld devices [3], [4].

The healthcare industry problematically experiences a high level of fragmentation that results in inefficiencies [5]. Most healthcare providers practice in silos in private practices. Also, health ICT systems have been implemented in silos. The balkanization of the ICT infrastructure in the healthcare industry amplifies the fragmentation [6]. The use of diverse ICT systems that are not capable of communicating with each other has been a serious problem in health care, especially when the care of a patient is shared between different healthcare facilities. Thus, a key step in fixing the healthcare delivery system is the adoption of common electronic and linguistic communication standards [7].

III. HEALTH INFORMATION AND COMMUNICATION TECHNOLOGIES

A. Electronic medical record systems

An electronic medical record (EMR) is health information relating to a patient. An electronic medical record is an electronic derivative of the chart that healthcare providers and their medical facilities keep internally on every patient [8]. EMR systems are used to generate, capture and manage health information. When used effectively, EMR systems improve the quality of care, generate savings, and improve clinical outcomes which result in higher patient's satisfaction.

The problem is that there are disparities in the use of EMR systems across the globe. Some countries, such as New Zealand and Denmark, have high rates of EMR functionality in widespread use [9], [10]. Denmark has highly functional EMR systems which are used by nearly 100 percent of primary care providers [11]. However, other countries, like Canada, experience a slow adoption of EMR systems. The Canadian healthcare industry is far behind other industries with regard to the use of new health information sharing technologies [12]. The Canadian healthcare industry is lagging behind other countries in adopting new information sharing systems, such as EMR systems [13].

One of the weaknesses of stand-alone EMR systems lies in their limited scope. Health information in EMR systems can only be accessed by authorized healthcare providers within the healthcare organization. Connecting EMR systems to Electronic Health Record (EHR) systems is to some extent the solution to the fragmentation and the balkanization experienced in the healthcare industry.

B. Electronic health record systems

An electronic health record (EHR) is health information relating to a patient which is generated, managed, and used by authorized healthcare providers across multiple medical facilities. An EHR is a patient-centric longitudinal electronic record containing health information from multiple EMR systems; this electronic record is shared across medical facilities [14]. EHR systems are used to facilitate patients' safety and improve the quality of healthcare delivery [15].

In some literature, an EHR is referred to as: Electronic Patient Records, Computerized Patient Record, Patient Care Information Systems, Electronic Medical Record, and Health Information Systems [16]. An EHR is viewed as a central technology in supporting the examination, treatment, and care of the patient. Electronic health records reside in electronic health record systems whose goal is to support medical facilities through enabling access to health information [17].

An electronic health record is used as a source of information regarding a patient's health and as a documentation tool [18]. Thus, it is considered as one of the most critical systems in eHealth. When used effectively, EHR systems make health information of relevance for the decision-making process available at the point of care. EHR systems provide healthcare providers with access to a patient's complete chart with detailed medical history [19]. A study on frail seniors conducted in the Canadian province of Quebec revealed that participants believed that their health information circulated faster among healthcare providers and among medical facilities thanks to the use of the electronic health record [20].

Although other industries such as banking and aviation have transitioned to electronic records and mobile technologies, the healthcare industry has been slow to embrace electronic records and suffers thereby from an inherent (but curable) fragmentation.

C. Personal health record systems

A personal health record is an electronic record of health-related information about a patient from several sources; patients are responsible for managing, sharing, and controlling their personal health records [21]. It is widely believed that these health ICT systems have the potential to revolutionize health care and enhance quality of health care. This is possible because PHR systems can 1) engage patients in their care, 2) improve communication between patient and physicians, 3) improve health outcomes, and 4) reduce health costs. As personal health record (PHR) systems can help patients and physicians develop new collaboration means and provide the basis for widespread health care transformation [22], they bring revolution into health care.

By transforming health care in terms of the relationship between healthcare providers and healthcare consumers, PHR systems have the potential to address one of the needs or expectations of today's patients: health consumerism. With the increase of health consumerism, patients want to participate in and influence decisions about their own care [23]. By improving communication between individual and healthcare providers, PHR systems increase patient's participation in health care. The implementation of personal health portals allows patients to use PHR systems regardless of time and location. When used effectively, PHR systems empower patients to play a critical role in the improvement of their safety by becoming actively and proactively involved in their health management. PHR systems enable healthcare consumers to have on-demand access to their health information for more effective decision making.

Despite these benefits, the adoption rate of PHR systems remains relatively low amongst healthcare consumers. The causes for the low adoption are several. Factors such as the possible digital divide, privacy and security concerns, user interface and usability issues, patient engagement, and computer illiteracy, have bearing on PHR systems adoption [24]–[27]. Also, individuals such as seniors and low-income patients, who can benefit the most from PHR systems, may be the least able to use them because of their limited access to computers and the Internet [28]. Another barrier to the widespread adoption of PHR systems consists of healthcare providers questioning the reliability of data generated by patients [29]–[31].

IV. HEALTH ICT IN SUPPORT OF PHYSICIAN-PATIENT PARTNERSHIP AND SELF-MANAGEMENT

A. Physician-patient partnership

Physician-patient partnership is critical to improving healthcare delivery. Patients' involvement in their care process improves the quality of care they receive. This involvement can be as simple as providing feedback about their experience during medical consultations. To drive quality, patients should become active participants whose responsibility consists of working with their healthcare providers towards their treatment goals. Encouraging patients to check their blood pressure and provide their healthcare providers with the readings on a regular basis is one of several examples of patients' participation in their care. Building working partnerships in the provision of care to patients is thought to be a useful approach to improving the quality of healthcare delivery [32].

There is a necessity to foster effective collaboration among healthcare professionals prior to building external partnerships with healthcare consumers. ICT systems such as EMR and EHR have the potential to improve collaboration among healthcare professionals. EMR systems facilitate communication and health information sharing among healthcare providers within the same medical facility. EHR systems provide a basis for a broader collaboration by facilitating health information sharing across several medical facilities.

PHR systems play a key role in building working partnerships between healthcare providers and patients. This is possible because PHR systems facilitate health information sharing between healthcare providers and patients. When used effectively, PHR systems provide patients and healthcare providers with the means to develop effective collaboration.

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Effective use of PHR systems has the potential to transform the relationship between healthcare providers and patients and meet two requirements of the present century: effective physician-patient partnership and uninterrupted healing relationship.

PHR systems benefit both patients and their healthcare providers. The use of PHR systems to support patients' self-management enlarges the reach of healthcare providers as it allows effective exchange of health information between patients and healthcare providers [33]. Also, as healthcare providers begin to view the patient as a partner in health care processes [34], an improved communication between healthcare providers and their patients becomes essential for effective partnerships.

Effken and Abbott [35] are of the opinion that integrating PHR with EHR systems has the potential to facilitate partnership between healthcare providers and their patients. An effective integration of EHR and PHR systems has the potential to profoundly transform the relationship between healthcare providers and patients and meet three main requirements of the twenty-first-century's healthcare. Those requirements include 1) effective physician-patient partnership, 2) patient self-management, and 3) uninterrupted healing relationship.

According to Tang and Lansky [36], new approaches to better health care should allow for an uninterrupted healing relationship between healthcare providers and healthcare consumers. Integrated health ICT systems in support of uninterrupted connectivity can play a crucial role in this regard.

B. EHR-PHR integration

From most patients' perspective high-quality health care would signify, to some extent, faster access to quality medical services. In this information technology era, patients should be able to interact with their healthcare providers without the hardship of travel. Integrating health ICT systems opens the possibilities of providing 1) integrated and coordinated health care and 2) improved quality of care. Susilo and Win [37] argue that advancement in ICT systems has led to collaborative research work and storage of health data in a single research database. A centralized research database results in improved patient-oriented care [38].

The integration of EHR and PHR systems allows patients to have access to some medical services at distance. It also provides healthcare providers with more time to spend with patients who require face-to-face consultations. Integrating EHR systems and PHR systems empowers patients as it allows them to collaborate with their healthcare providers as equal partners. Allowing a secure link between PHR systems and EHR systems provides patients with full access to their medical charts. Such access provides patients with several benefits.

First, it allows them to review their prescription history, medical notes, laboratory test results, and diagnostic imaging results. Second, it allows them to learn who has accessed their medical records. Third, web-based PHR systems enable patients to request and consume some health services available online from anywhere at any time. For instance, health services, like the booking of medical appointments or prescription refills, can be consumed online. In a study to measure the adoption and use of a patient Web site, patients recognized that PHR systems integrated with EHR systems were helpful in obtaining scripts for medical prescription refills and easing secure messaging between themselves and their healthcare providers [39].

To reap the above benefits, fragmentation experienced in the healthcare industry must be addressed effectively. To flatten the healthcare landscape, four requirements must be met: First, the integration of all EHR systems presently built in silos is essential. Second, the adoption of common electronic and linguistic communication standards is needed. Third, the use of a seamless and secure cross platform to support EHR systems and a broad range of handheld devices used by healthcare providers and patients is required. Fourth, integrated systems require either the use of a shared database or an effective exchange of health information housed in the databases of the systems involved.

In Canada for instance, the absence of pan-Canadian EHR standards [40] has had a negative impact on the quality of healthcare delivery. It is widely believed that the Canadian healthcare system will benefit from the implementation of a national database to hold provincial and territorial health data. The absence of standard measurements, however, has resulted in the impossibility to implement an effective national health database. For the past decade, federal, provincial, and territorial governments have invested significantly to accelerate the development of EHR systems, common information technology standards across the country. It is believed that, once completed, this undertaking will flatten the Canadian healthcare landscape and improve healthcare delivery for all Canadians.

C. Increased health consumerism

With the increase of health consumerism, patients want to be active participant in their care; and they like to influence decisions relating to their own care [41]. As they have the potential to improve communication between individuals and their healthcare providers, ICT systems, like PHR, increase patient's participation in health care. Grossman *et al.* [42] believe in the potential of health ICT systems to engage patients in their health care and increase their satisfaction. The implementation of personal health portals allows patients to use PHR systems irrespective of time and location.

Gonzalez [43] argues that providing individuals with means that empower them to become better healthcare consumers is crucial to promoting consumerism. ICT empowers patients to play a critical role in the improvement of their safety by becoming actively involved in their health care [44], [45]. With PHR systems acting much like automated teller machine cards, health consumers have the ability to access their own personal health information and a variety of other health services anytime and anywhere [46]. In the Danish healthcare system, for instance, ICT has empowered patients to improve

self-care by allowing them to review their health information such as, laboratory results and prescriptions [47]. In the U.S. healthcare system however, despite the increase of health consumerism that requires patient's participation in decisions regarding their health care [48], ICT systems have not empowered patients yet. The reason is that most U.S. medical facilities have not adopted patient online services yet [49].

V. HEALTH ICT IN SUPPORT OF UNINTERRUPTED CONNECTIVITY

A. Sensor and wireless technologies

The use of wireless, sensor, and portable device technologies can enable individuals to provide constant services to their organizations. Wireless access points, and temperature and location sensors points can be embedded in the environment to automatically connect individuals entering the environment [50]. By allowing personal computing devices to be adapted to the context, sensors and wireless access make crucial information readily available to information seekers to deal with the tasks at hand. With standard encryption protocols, wireless access points can be as secure as wired networks.

A crucial step toward the realization of this universal environment is timely sharing of relevant information to information seekers [51]. Two approaches are usually used in the dissemination of data to mobile clients. One approach, known as on-demand access, uses point-to-point connection, in which a mobile client sends a request to the server. The server processes the query and returns the results directly to the mobile client. The second approach is known as periodic broadcast or data broadcast. In this approach, the server determines data to broadcast and their schedule on the wireless channel. It is the mobile client's responsibility to listen to the channel and determine data to retrieve.

On-demand access provides rapid service in a system with relatively small number of queries from clients. The performance of on-demand access declines with the increase of the system workload because of the competition for bandwidth among the mobile clients. In general, data broadcast or periodic broadcast is an interesting alternative to on-demand because of its potential to broadcast data concurrently to a large number of clients.

The benefit of this pervasive environment in the healthcare industry is the ubiquitous health information access by healthcare stakeholders. Timely and relevant health information is easily disseminated to healthcare providers, healthcare consumers, policy makers, and decision makers regardless of time and location. Also, ICT systems in support of distributed health teams must allow for uninterrupted medical services. By using portable devices, wireless, and sensor technologies to implant computing technologies transparently in their environments, healthcare systems can provide patients with around-the-clock medical services.

B. Distance-irrelevance and mobile connectivity

As the globalization of work has transformed the workplace into a transparent landscape with less reliance on physical location, effective knowledge distribution requires systems that can span distance. "Wireless networking and portable digital devices provide people with unrestricted mobility" [52]. ICT in support of distributed teams must have two main attributes: distance-irrelevance and unrestricted connectivity. As distance-irrelevant ICT eliminates time and space boundaries, organizations can benefit from the knowledge and expertise of their dispersed knowledge workers [53]. Cost and time savings are additional benefits that can be derived from the use of distance-irrelevant ICT systems as they reduce the need for face-to-face meetings.

ICT systems in support of distributed health teams must allow for uninterrupted services and mobile connectivity. As noted earlier, the emergence of portable devices, wireless, and sensor technologies has enabled individuals to embed computing technologies transparently in their environment to provide uninterrupted services. Thanks to temperature and location sensors, and wireless access points implanted in the environment, healthcare providers and patients entering that environment automatically connect to it. Sensor, wireless, and portable device technologies can allow personal computing devices to adapt to the context and to make relevant information readily available to healthcare stakeholders. Such pervasive environment provides healthcare providers, healthcare consumers, policy makers, and decision makers with access to relevant health information to tackle the tasks at hand in spite of their location.

C. Cloud computing

Cloud computing is a business and service model in which ICT resources and related services are treated as a consumption-based service. Cloud computing allows organizations to use networks, servers, data storage, software, hardware, and technical support as a utility. One of the benefits of using cloud computing is that organizations can focus on their core competence.

There have been talks about integrating health ICT systems, like EHR and PHR, with the cloud. These talks have some merit as cloud computing has the potential to provide healthcare systems around the world with several benefits both at the micro and macro levels.

At the macro level, cloud computing can help deploy easily EHR systems in a cost-effective way. Cloud computing pay-as-you-grow billing model can address two big factors that impede the implementation of EHR systems in this recovering economy: increasing costs of health care and insufficient financing.

At the micro level, using cloud-based electronic medical record systems can be extremely cost-effective. Most private medical practices generally do not have the technical expertise required to support new technologies. Cloud computing removes the burden of hiring internal ICT expertise to maintain and service in-house infrastructure for EMR systems and other applications used to better healthcare delivery. Moreover, small hospitals and private medical practices lack sufficient funds to purchase *state-of-the-art* health ICT. In the cloud computing business model, the pay-as-you-grow billing

model will provide these hospitals and medical practices with opportunities to use modern health ICT systems without purchasing them. Thus, the cloud computing model can help medical practices maximize infrastructure usage, reduce marginal operating costs, and improve medical services delivery in term of quality and timeliness.

Cloud computing can help implement a shared database that can facilitate public health research, health services research, and clinical research. Integrating EHR systems with the cloud provides healthcare systems' stakeholders with access to health information stored on a remote secure server via either web browser or mobile devices, such as smart phones or tablets. One of the benefits derived from the use of cloud is the limitless amount of space available to store health information. Interest in using cloud computing in health care is quickly increasing.

However, perceived challenges, such as security and ownership of data, stand in the way of achieving the above-mentioned benefits that cloud computing promises. According to a survey conducted by PhoneFactor [54] in 2010 in the U.S., security was the primary hindrance to cloud computing adoption, followed by compliance, portability, and data ownership. A study conducted by the International Business Machines Corporation reveals that 77 percent of respondents believe adopting cloud computing makes protecting privacy more difficult [55]. The same study suggested that 50 percent of respondents are concerned about the potential for a security breach or data loss on the cloud.

The majority of people are of the opinion that security measures for cloud and EHR integration are still in their infancy [56]. As a result, the integration of EHR systems with the cloud has been slow. Findings from the 2013 Technology Survey, sponsored by ZirMed, reveal that 32 percent of the respondents use cloud-based electronic health record systems [57].

In the U.S., the use of cloud computing in health care is seen as a means to help comply with some security concerns stipulated in the Health Insurance Portability and Accountability Act regarding the mobile health world [58]. Whereas, in Canada for instance, concerns about compliance with the Canadian Freedom of Information and Protection of Privacy Act regulations remains one of the most significant hindrances to cloud computing adoption in the Canadian healthcare system. The idea of moving most or all of health care providers' ICT resources, including health data storage, to a cloud service provider remains a cause for concern in the Canadian healthcare system. Furthermore, one of the biggest concerns is the U.S. Patriot Act. Canadians believe that the U.S. Patriot Act can violate the privacy of their health information stored by U.S. cloud providers.

VI. MOBILE CONNECTIVITY

A. Virtual Team and mobile connectivity

The world economy has given rise to virtual and mobile teams. Today, virtual and mobile teams are increasingly becoming a standard and effective way of working. To carry out their duty in an effective way, global organizations' decision-makers and global teams' members need mobile connectivity systems. According to Zheng and Lun Lee [59], wireless networking and portable digital devices provide individuals with unrestricted mobility. Mobile computing devices include mobile phones, personal digital assistants, patient monitoring devices, and other wireless devices. As the information age call has been to develop virtual organizations [60], distance-irrelevant information systems and mobile technologies are crucial to organizational performance.

The impact of mobile connectivity on health care is multifold. As distance-irrelevant ICT systems help eliminate time and geographic boundaries, healthcare organizations can benefit from the knowledge and expertise of healthcare professionals dispersed across the globe. Furthermore, medical functions can be performed anytime and anywhere thanks to the use of the Internet technology. Moreover, ICT systems in support of virtual teams in health care have the potential to provide the healthcare industry with cost and time savings by reducing time to travel for consultations.

B. Real-time systems and trust-building in health care

However, working over long distances could present challenges for collaboration, effective information sharing, and trust building. As communication helps resolve problems and avoid misunderstandings, ICT systems that support synchronous and effective interactions have the potential to help build relationships in a virtual team environment. Being able to ask questions and receive answers in real-time helps build trust. Thus, real-time systems are needed to support today's health care which is expected to be delivered in a team-oriented work environment.

The use of mobile technologies in the delivery of health care is referred to as mobile health (mHealth). Mobile phone's simple utilities, such as voice and short messaging services, can be used in the provision of health care. Mobile health can also include more advanced functionalities and applications, such as space-based satellite navigation systems, smart phones, and Bluetooth technologies. To improve healthcare delivery in terms of availability of health information, containment of health costs, and reaching populations in underserved regions, eHealth should be supported by the use of mobile technologies.

VII. MOBILE TECHNOLOGIES REVOLUTION IN THE HEALTHCARE INDUSTRY

A. Healthcare fragmentation

A review of literature reveals that health care in most countries is fragmented and experiences significant disparities. In the U.S. for instance, the healthcare landscape has been characterized by some racial and ethnic disparities [61]. The discoveries of Sehgal [62] reveal that the U.S. healthcare system is characterized by the presence of disparities based on sex, race, type of health insurance, socioeconomic status, and some other relevant grouping. These findings were similar to that of Effken and Abbott [63] who found that the U.S. healthcare landscape was characterized by geographic

disparities.

Effken and Abbott [64] opined that there is a disparity in healthcare delivery as rural communities experience shortage of healthcare providers. Although 20 to 25 percent of the U.S. residents live in rural regions [65], only 9 percent of healthcare providers practice there. Also, about 22 percent of primary care providers in the U.S. provide care to over 80 percent of older African American citizens [66]. The shortage of healthcare providers in outer urban communities has deteriorated healthcare delivery in rural regions of America.

Like the U.S. healthcare system, the Australian health care system experiences location disparities in the provision of health care. In comparison with metropolitan regions, access to medical services and health outcomes are in most cases poorer in remote and rural regions where nearly 33 percent of Australian residents live [67]. In response to geographic disparities, the Australian healthcare system leaders have looked to ICT as a means to overcome distance and improve healthcare delivery [68]. From a review of literature, patients living in remote, regional and outer metropolitan areas have been given the opportunity to tele-health. Australians are now allowed to have video consultations with specialist physicians. This initiative is intended to provide patients living in rural regions with easier access to specialized care without hardship of travelling to major cities [69].

A study conducted in 2005 in the U.S. led to the understanding that health ICT systems allow the advancement of modern medicine into remote and rural regions [70]. In 2009, another study conducted in the U.S. suggested that EHR systems have the potential to connect the U.S. healthcare landscape [71]. These two studies led to believe that EHR systems have the potential to enhance the quality of care in both urban and rural communities. From these studies, it can be concluded that effective use of EHR systems is crucial to addressing disparities experienced in healthcare systems.

It is worth noting that the success of EHR systems depends in part on the adoption of EMR systems. The problem is that the adoption of EMR systems has been slow in several countries, and that health facilities that have adopted EMR systems are working in silos. Also, a review of literature suggests a slow adoption of EMR systems in rural regions of some countries.

In the U.S., for instance, there is a slow adoption of EMR systems in rural areas, where 41 percent of community health facilities are located [72]. Recommendations have been made for U.S. federal and state governments to join hands with the private sector to expedite the adoption of EMR and EHR systems in the rural regions of the U.S. [73]. Ensuring equal access to electronic health records is considered as an essential part of reducing disparities experienced in the U.S. healthcare system [74]. For this reason, George W. Bush signed an execution order on April 27, 2004 to establish within the Department of Health and Human Services the position of National Health Information Technology Coordinator. One of the responsibilities of the coordinator is to ensure the utilization of EHR for every single person in the U.S. by 2014 [75].

Several surveys and recent data from the U.S. federal government indicate that the adoption of EHR systems has significantly increased since 2009. A study conducted in the summer of 2012 by MedScape, a research firm, suggested that more than 80 percent of physicians were using EHR systems [76]. A similar study conducted in 2009 indicated that only 38 percent of healthcare providers were using EHR systems. These two studies show that the adoption rate of EHR systems has more than doubled in the U.S since 2009.

Like in the U.S., the Canadian healthcare delivery system is fragmented. There are disparities among provinces in the quality of healthcare delivery. There are also inter-regional disparities within provinces or territories. Findings from a study conducted by Ravenscroft indicated that poor information management and ineffective communication among healthcare providers affect the continuity of patient care [77]. In response, the Canadian healthcare system has promoted the development of interoperable EHR systems, which have the potential to allow seamless health information sharing among healthcare providers. As the future of the Canadian healthcare system is expected to be very much influenced by the EHR systems [78], all levels of Canadian governments have invested significantly to achieve the goal of providing 50 percent of Canadians with adequate EHR systems by 2010 [79].

Although progresses are being made in this area, the attainment of this aggressive goal was constrained by several factors [80]. These factors include among others: insufficient financing, complexity of requirements relating to data portability, slow rates of adoption, and concerns relating to privacy. With respect to slow adoption rates and privacy concerns, about 53 percent of Canadian patients would not want their health information in the government EHR systems [81]. Also, 52 percent of primary care providers would not upload health information without patients' specific consent [82].

To address security issues that impede a widespread adoption of EHR systems in Canada, it has been recommended that the current focus be shift from the promotion of EHR to the protection of health information that EHR systems are expected to manage [83]. This shift is believed to result in increased adoption of EHR systems across Canada. Two more solutions have been put forth to promote the use of EMR and EHR systems in the Canadian healthcare system. First, healthcare providers should be provided with the right incentives to adopt health ICT systems. Second, under the single-payer system, the use of EMR and EHR systems can be enforced. In some provinces, healthcare providers are required to submit their request for payment electronically.

B. Mobile health and global healthcare landscape

The use of mobile technologies to address healthcare issues has evolved into a new field, known as mobile health. Mobile health has the potential to address the disparities experienced in the provision of health care either within the same country or across the world. Mobile computing devices, such as mobile phones and smart phones, offer several significant

advantages over other forms of digital technologies for public health advance. Mobile phones and smart phones can help reach populations in underserved areas [84].

This is possible for three reasons. First, smart phone applications can be used to download EHR and PHR systems. Second, over five billion people across the world use wireless devices. Third, the commercial wireless signals coverage represents over 85 percent of the world's population [85], [86]. So, mobile health can considerably improve healthcare delivery around the world. The benefits derived from the use of mobile technologies in the healthcare industry include health costs containment, timely access to care, and enlarged reach of healthcare providers.

Today, several developing countries are witnessing a significant penetration of mobile phone networks. The increasing reach, potential, and availability of mobile devices are making them the platform of choice for functions once limited to work computers. The evolving sophistication of mobile applications and healthcare databases has the potential to transform the way health information is accessed, delivered, and managed.

C. Mobile health improves health care

Wireless and mobile technologies provide a new frontier in delivering better care and services to patients [87]. The use of wireless and mobile technologies in the healthcare industry provides patients and healthcare providers with timely access to critical and real-time health information. Moreover, when integrated into patient care, wireless and mobile technologies allow healthcare providers to monitor patient's health conditions from anywhere. The use of mobile devices in health care improves the efficiency of health information sharing as they can provide healthcare providers and patients with on-the-run learning opportunity. Also, during natural or human calamities, mobile health provides a clear-cut and substantial advantage over other traditional healthcare delivery methods.

Today, healthcare providers want timely access to health information in order to deliver better care to patients. Literature suggests that the emergence of online enquiries and *real-time messaging* services for web-enabled devices has extended the need of healthcare providers, like New Zealander physicians, for instantaneous access to health information [88]. More than 80 percent of New Zealander primary healthcare providers are currently using web-services technology and the first of a new generation of *real-time messaging* services [89].

Mobile technologies and decision support systems have the potential to allow individuals to manage some health problems more effectively on their own. These technologies not only improve self-care but also they provide healthcare stakeholders with on-the-fly access to critical health information. Mobile technologies can help individuals take more initiative in managing their overall health. Most importantly, they can help people proactively communicate with their healthcare providers for either preventive care or specific interventions when certain criteria thresholds are met.

D. Rise of a new healthcare model

Mobile health has the potential to bring transformation in health care to meet the requirements of the twenty-first century's healthcare delivery. Literature reveals that, in the U.S. for instance, mobile health technologies, such as tablet computers, smart phones, and cloud computing, have revolutionized healthcare providers' interaction with their clients and the whole delivery of health care [90]. When used effectively, mobile health can transform the traditional health care model. Instead of seeing their healthcare providers only when they need medical treatment, patients are expected to become more active and proactive partners in their care. In other words, mobile health has given rise to a new health care model, one in which patients have become partners pursuing the common and ultimate goal of staying healthy.

Mobile health is viewed as a catalyst for switching to a new health care model that can satisfy the current expectations of all healthcare stakeholders. These expectations include among others 1) patient's self-care, 2) effective health information sharing, 3) eradication of disparities experienced in healthcare delivery, 4) increase of health consumerism, and 5) containment of health costs and, at the same time, improvement of the quality healthcare delivery.

Mobile health has the potential to link diverse areas of health care within a continuum of care. Those areas include, among others, healthcare providers and patients' education, healthcare stakeholders' collaboration, and patient care. Mobile health enables healthcare providers to interact with their patients continuously. Such interaction results in an uninterrupted healing relationship between patients and their healthcare providers, which is much needed today.

VIII. CHALLENGES AND ISSUES

A. Human factors and perceived risks

Although mobile health promises enormous technological capabilities, the 'patient' component remains without question critical to the success of any mHealth enterprise. Even though people are increasingly feeling comfortable with mobile banking, patients have been reluctant to use mobile health due to security and privacy concerns. These concerns include the potential risks and vulnerabilities associated with remote access to, and offsite use of patient information.

To meet around-the-clock and mobile connectivity requirements, mHealth provides healthcare providers with the opportunity to use smart phones and wireless handheld devices to interact with their colleagues and patients, or to access patient health information. Although these devices provide a convenient way to access, process, and share health information, smart phones and wireless handheld devices have become attractive to hackers because of their advanced Internet features, like Web browsing [91]. Mobile communication devices used by healthcare providers and patients, such as tablet computers, Blackberry, and other smart phones, can put healthcare facilities' networks at risk and compromise health information privacy. Most of these perceived threats come from either the ignorance of users or

improper security implementation.

So, the success of mobile health undertaking depends on the way real and perceived security concerns are addressed. As smart phones pose security concerns, increasing use of mobile banking has forced banks to spend more money to address security threats [92]. Thus, the development of mobile technologies to support healthcare delivery must take into consideration real and perceived security concerns.

Some people are of the opinion that cloud-based mHealth can address most security issues. The argument is that, with cloud-based mobile computing, little data relating to patient health will be stored on handheld computing devices [93]. In other words, little health information will be at risk for theft because handheld computing devices will be used mostly as a presentation layer of an n-tier architecture. Still, sufficient end-to-end data encryption will be needed to protect health information during the transmission.

B. Bluetooth attacks

Bluetooth is an open standard technology that uses radio frequency to establish short-range wireless communication. This technology enables mobile computing devices to establish on-the-spot network connection wirelessly [94]. For this reason, Bluetooth has become a famous technology since its launch. It has found its way into everything from smart phones to other computing devices. This advance has made Bluetooth a primal target for hackers [95].

Like every technology, Bluetooth has its weaknesses. All of the hacking problems that are related to computers are valid for smart phones and Bluetooth. Loo [96] argues that, if used properly, risks of using Bluetooth and smart phones are relatively low compared with those of other technologies.

Bluetooth attacks often target mobile devices that have little or no security features. Bluetooth attacks affect only a little number of computing devices within a limited proximity to the attacker. This makes it difficult to assess the real damage caused by hackers abusing this technology [97].

C. Available Internet bandwidth

Although many developing countries are witnessing a proliferation of mobile devices whose software applications can advance healthcare delivery, their citizens often use mobile-broadband networks as a main method to access the Internet. There are disparities between regions in terms of available Internet bandwidth per World Wide Web (W3) user. For instance, a European W3 user uses on average almost 90,000 bits per second of bandwidth, whereas the average is 2,000 bits per second per user in Africa [98]. This puts developing countries at a disadvantage.

IX. Convergence of Challenges And Issues in Health Care

A. ICT-related Risks and Healthcare Delivery

Undeniably, challenges and issues relating to the use of ICT in health care have bearing on healthcare delivery if they are not properly addressed. Electronic health raises concerns about the protection of health data. These concerns have impeded the adoption of ICT in health care.

In spite of numerous benefits that health research databases (HRDBs) provide, their use introduces new challenges. As HRDBs contain longitudinal health information about health status of individuals and their identifiable information, their protection is crucial to their adoption. Furthermore, the use of the Internet technology in health care has introduced security and privacy risks that must be addressed. Moreover, because of their dynamic topology, severe resource restrictions, and lack of a trusted infrastructure, wireless sensor networks present new security challenges that must be overcome [99].

The need for uninterrupted and mobile connectivity in health care amplifies security and privacy concerns. Concerns about the security and privacy of health information are greater in mobile health because of the use of portable computing devices that can be stolen easily. Also, portable computing devices, such as smart phones and tablets, are vulnerable to hackers' attacks. As a result, individuals, who use mobile banking, are reluctant to use portable computing devices in the provision and consumption of medical services.

B. Internet bandwidth and healthcare delivery

Despite the proliferation of mobile technologies across the globe [100], the existence of significant disparities in the available internet bandwidth among countries results in unequal access to medical services. A review of literature reveals that individuals living in previously unconnected regions of developing countries use mainly mobile-broadband networks to connect to the internet. The competition for limited bandwidth among the mobile devices' users has a negative impact on patient's access to medical services delivered online.

As a result, people who can benefit the most from mobile health, may be the least able to reap several benefits that mobile technologies promise in health care. Undoubtedly, the use of mobile-broadband networks, as a main method to access the World Wide Web, and their bandwidth capacity have bearing on healthcare delivery.

C. Bluetooth attacks and healthcare delivery

Bluetooth's use of peer-to-peer ad hoc wireless network makes it an easy-to-use and vulnerable technology at the same time [101]. To communicate, two mobile computing devices in the same physical area need just a Bluetooth radio and Bluetooth software. The lack of centralized administration and the absence of security administration infrastructure are the main sources of Bluetooth's security vulnerabilities. Today, the need to secure this open standard technology is more urgent than ever to promote the adoption of mobile technologies in health care.

The degree of mobile computing devices' adoption in health care depends on the way Bluetooth attacks are addressed. To see a widespread adoption of mobile technologies in health care, real and perceived risks relating to the security and privacy of personal health information must be addressed in an effective way.

D. Human factor and healthcare delivery

To reap the benefits that mobile technologies promise in the provision and consumption of medical services, health ICT manufacturers, healthcare providers, and healthcare consumers are expected to play a critical role. There is a necessity to ensure the confidentiality of health information in order to boost the adoption of mobile technologies in health care.

The protection of personal information should be at the heart of any attempt to develop health ICT systems. Therefore, health ICT manufacturers should embed privacy in all phases of health ICT systems' development. Designing a system architecture that provides mobile computing devices with a secure connection to EHR systems would minimize risks of privacy breach. Moreover, strong end-to-end encryption is needed to protect health data during their transmission. Furthermore, to improve patient privacy, ICT manufacturers should design health ICT systems with effective authentication technologies, such as smart cards, tokens, one-time password, badge readers, and biometrics.

Healthcare providers must integrate privacy into their clinical processes and practices. They should protect smart phones and tablets they use in their practice to prevent loss or compromise of patient health information. For this reason, mobile devices used in the provision of health care should not be left accidently in a public location. Also, healthcare providers should disable Bluetooth on their mobile computing devices whenever they are not used to provide medical services. This best practice has the potential to minimize hackers' access to patient information.

To boost the use of mobile devices in the consumption of health care, public education is needed. Healthcare consumers are responsible for managing, sharing, and controlling their personal health records. For this reason, they should be aware of the prevalence of mobile computing devices' theft. Patients are responsible for protecting handheld computing devices they use to consume medical services. Also, they should learn the necessity to create strong passwords to address some security and privacy concerns. Strong passwords prevent the use of their portable computing devices by unauthorized individuals.

X. Conclusion

Views expressed in literature suggest that the use of ICT in health care has the potential to improve healthcare delivery. When used effectively, health ICT systems can help contain health costs, expedite access to primary and specialized care, make relevant information available to healthcare stakeholders, and facilitate physician-patient partnerships. Health ICT systems have the potential to improve patient-oriented care, offset the shortage of healthcare providers, and enhance healthcare system functioning. The use of internet-based systems in health care can improve information sharing among healthcare providers and between healthcare consumers and healthcare providers regardless of their locations. To meet the increasing health consumerism and patients' needs for active participation in their care, effective approaches to health system design should allow for an uninterrupted healing relationship between patients and their healthcare providers. For this reason, four critical steps to fixing inefficiencies experienced in healthcare delivery must be taken. First, as electronic health is critical to improving healthcare delivery, the healthcare industry should implement health ICT systems that can improve health information management. Second, EHR systems should be integrated with PHR systems to support effective partnership between healthcare providers and healthcare consumers. Third, there is a need for safe, uninterrupted, distance-irrelevant, and around-the-clock health ICT systems built on a seamless and secure cross-platform to support portable computing devices used in health care. Fourth, to meet the mobility requirements of the twenty-first century, eHealth should be supported by mobile technologies. Mobile health technologies have the potential to revolutionize healthcare delivery in terms of health cost containment, information management, and access to health care. The expansion of wireless scope and the increasing use of mobile devices across the world can have a positive impact on health care. By allowing previously unconnected regions of the world to communicate, mobile technologies have the potential to help flatten national and global healthcare landscapes. There are, however, several obstacles to overcome before their widespread adoption. Security, available Internet bandwidth, and lack of common standards are some of the key problems.

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