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Paradigm Shift in Healthcare through Technology and Patient-Centeredness

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Abstract

Amidst the background of numerous challenges confronting the healthcare sector (such as rising costs, chronic disease upsurge and issues related to patient safety), this narrative review aims to shed light on the opportunities provided by patient-centered care and technology use as a means to improve and reshape the healthcare sector. The evolution of technology use in healthcare from telemedicine to the present era of connected health is highlighted and discussed as a pertinent emerging model to strengthen the patient-centered care and link the components of the healthcare sector. Various trends in the technology arena which uphold the tenets of patient-centered care are also outlined. Lastly, some of the critical views about digitalization of health that have impeded the widespread adoption have been touched.

Keywords

Overview, Digital health, Connected health, Healthcare delivery

Introduction

The healthcare sector in the modern era, despite witnessing numerous breakthroughs in the field of medicine and pharmacology together with an astonishing healthcare expenditure which in the United States alone has stretched to $3.2 trillion in 2015 [1], reflects a grim scenario since affordable, accessible and quality healthcare to every segment of the population continues to remain a distant dream which is precipitated by the worldwide lack of highly skilled healthcare professionals [2]. Furthermore, modernization of lifestyle and a rapidly ageing population have set the conditions ripe for a plethora of chronic diseases such as cardiovascular diseases,

diabetes, and hypertension which require long-term continuous treatment and management leading to a substantial economic burden on the healthcare system as well as accounting for 70% of deaths globally [3,4]. To make matters worse, communicable diseases such as lower respiratory infections, diarrheal diseases, and tuberculosis continue to haunt global health by featuring amongst the top ten causes of death in 2015 and thus lead to a double burden of disease [5]. In addition to this, patient safety has become a burning issue, with the World Health Organization (WHO) estimating that 1 in 10 patients are harmed while receiving hospital care in developed countries due to preventable medical errors [6,7]. Moreover, antibiotic resistance has taken the medical world by storm owing to the overuse and misuse of antibiotics and it is projected that in the US nearly 23,000 deaths occur annually as a result of bacterial infections which are resistant to antibiotics and hence place a considerable load on the healthcare sector [8,9]. Lastly, the "silo" mindset rampant in the healthcare sector is a cause for concern since it leads to fragmented and uncoordinated processes of care thereby hampering the quality, efficiency, and safety of the care delivered [10,11].

Opportunities for Improvement in Healthcare

Patient-centered care

Against this disturbing background, there have been some reassuring prospects which have provided opportunities for the healthcare sector to make reforms. Firstly, in the face of the myriad of challenges

Al Muammar et al. Int Arch Public Health Community Med 2018, 2:015

• Page 1 of 8 •

confronting the healthcare sector, in a much-publicized landmark report, the Institute of Medicine suggested an approach for improvement and "crossing the quality chasm" by outlining six aims for healthcare to be safe, effective, patient-centered, timely, efficient and equitable [12]. Among the principles that had been proposed, the one that garnered most attention was the aim for health care to be "patient-centered by providing care that is respectful of and responsive to individual patient preferences, needs and values and ensuring that patient values guide all clinical decisions" [12]. Eight dimensions of patient-centered care as outlined by the Picker Institute include: 1) Respect for patients' values, preferences and expressed need; 2) Coordination and integration of care; 3) Information, communication and education; 4) Physical comfort; 5) Emotional support and alleviation of fear and anxiety; 6) Involvement of family and friends; 7) Transition and continuity 8) Access to care [13]. In addition, the WHO advocated people-centered care as a broad term to include patients at every level of the health systems and defined it as "care that is focused and organized around the health needs and expectations of people and communities rather than on diseases" [14,15].

Consequently, by bringing patient-centered health care to the forefront, the patient is no longer a passive recipient of healthcare services and the concepts of patient engagement and empowerment have gained ground since they embolden the role of patients to proactively participate in self-care practices especially in this age of chronic disease upsurge [16,17].

In recent years, research has provided compelling support in favor of patient centrism since it has been shown that implementing patient centered care is linked to greater compliance by the patients, better recovery and health outcomes and declined readmission rates [18]. For instance, a systematic review on the benefits of patient-centered care among patients with chronic heart failure revealed an increase in their quality of life, as well as a boost in their physical and mental status [19]. Effective communication between the doctor and patient by forging a better interpersonal relationship, information exchange and involving patients in decision making have been shown to improve patient satisfaction which is constructive for doctors since it leads to greater job satisfaction and reduced burnout [20]. Numerous monetary benefits have also been attributed to patient-centrism such as reduced hospital stay, lower cost per case, reduced operating costs and malpractice claims, all of which contribute to improving the quality of the healthcare delivered [21]. Evidently, a win-win situation at every level of healthcare has germinated as a result of this paradigm shift in healthcare delivery.

Technology use

The other beam of comfort lies in the information technology arena, whose epoch-making invention and development have been at the vanguard of human progress, in recent history. Today, technological advancements have made digital tools widely accessible and handy to the masses with approximately 46% of the world's population having access to the internet in 2016 [22] and nearly 7.683 billion people having mobile cellular subscriptions in 2017 [23]. Owing to this accessibility to the digital world, people have now become introduced to a boundless sphere of information, effortless communication, and endless opportunities by literally a click of the finger.

Harnessing upon this massive penetration, technology has been deployed in healthcare which was advocated by the Institute of Medicine as a vital means to accomplish the aforementioned six aims to improve quality in healthcare [12] and has shown compelling potential in mitigating the problems faced by the healthcare sector by enabling accessible, efficient and improved health outcomes [24]. Additionally, the WHO also resonated with the essential role of technology in realizing the 2030 Sustainable Development Goals related to health [25]. More particularly, the use of technology in healthcare upholds the tenets of patient-centered care by channeling new approaches to promote patient engagement and improve the communication between the patient and the healthcare professionals and consequently enhanced care [26].

Overview of Technology Application in Healthcare and its Evolution

A peek into the evolution of technology use in healthcare exhibits a dynamic and fascinating sequence of events that led to the digital health era as we know it, keeping in view the progress in technology has been exceedingly fast-paced and is increasingly orienting towards patient-centric principles. In the 1960s, coupled with the advancements made in information and communication technology (ICT) and the dire need to make healthcare accessible in remote regions, paved the way for technological application in the healthcare arena and the birth of *Telemedicine* which literally means "healing at a distance" [27] and according to the Institute of Medicine, it is defined as "the use of electronic information and communications technologies to provide and support health care when distance separates the participants" [28].

Soon after, it was recognized that the approach towards the remote provision of healthcare needed to encompass a more comprehensive outlook by incorporating non-physician related care such as nursing and pharmacy and elements of public health such as health education and health promotion to empower the patients for self-care. This broader scope of telemedicine was coined as *Telehealth* [29,30].

The turn of the century witnessed a colossal upsurge of the internet and every sector including healthcare

went on board to benefit from the fresh opportunities that now lay before them. This led to the rise of *Electronic Health (eHealth)* which is defined as "an emerging field in the intersection of medical informatics, public health, and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology" [31].

But what may be considered a game changer was the proliferation of mobile phones into the hands of a common man. Capitalizing upon this accessibility to technology, the healthcare sector found new ways to address the healthcare challenges facing them, heralding the rise of *mobile health (mHealth)* which is a subset of eHealth and provides medical and public health services and information via mobile technologies such as mobile phones and personal digital assistants (PDAs) [32]. mHealth offers a means for healthcare professionals to keep their patients updated via reminders, alerts and health-related information [33]. Multiple studies have focused on the role of mobile SMS as a means for impelling behavior change, self-efficacy and improving knowledge in areas such as sexual and reproductive health [34].

With the coming of the Internet of Things (IoT) into the technology scenario, it became possible to create a network between different devices through software's, sensors and network connectivity thereby enabling an exchange of data between them [35]. This propelled the rise of *Digital Health* which is defined as "an improvement in the way healthcare provision is conceived and delivered by healthcare providers through the use of information and communication technologies to monitor and improve the wellbeing and health of patients and to empower patients in the management of their health and that of their families" [36] and includes categories such as mHealth, health information technology (IT), wearable devices, telehealth and telemedicine, and personalized medicine [37].

In recent times, with the realization of bringing patient-centric values of patient engagement and empowerment to the forefront, adoption of the latest technology in health care and recognizing the need to ward off the perils of a disassembled healthcare sector, a new sociotechnical concept of "*Connected Health*" came into being with the aim to make health and wellness services safe, effective and efficient and as a result enhancing the quality of life and lowering the costs [38]. Connected Health, an overarching model that includes all aspects of technology use in healthcare such as telemedicine, telehealth, mHealth, and eHealth, mirrors a distinct balance of technology use for information sharing and connectedness together with proactive care and integrated healthcare services [39]. Moreover, it has opened up a new vista in healthcare by digitally connecting clinicians to clinicians, patients to clinicians and patients to other patients [30].

Consequently, as an era of connected health beckons, lured by an exciting prospect of long-term wellness of the patient and enhanced outcomes, prominent health technology companies such as Philips [40] and Partners Healthcare [41] have launched their respective Connected Health platforms. Additionally, in the Middle East, RAHAH (Remotely Accessible HealthCare At Home), a novel connected health model from Saudi Arabia, is all set to carve a niche for itself in this ever-evolving ecosystem [42-44].

Trends in the Digital Health Landscape Today

e-Patients, e-Physicians and smart hospitals

In accordance with patient-centered care, a partnership has developed between the patient and provider and a patient is encouraged to proactively participate in disease management as well as being engaged in the decision-making process. Moreover, a patient now increasingly resorts to the internet to seek health information. As a result, a patient today is "empowered, engaged, equipped, and enabled" besides being digital health-savvy leading to the birth of an e-Patient [45].

Slowly but surely, technology is being endorsed and implemented by the doctors as well. e-Physicians are increasingly leveraging from the opportunities conveyed through smartphones in clinical decision making and better care coordination through smarter scheduling and organization of their tasks [46,47].

Hospital facilities too are progressing in parallel by utilizing technological innovations to enhance the care and safety of the patient during their stay at the hospital, for instance, by installing automation systems in the building to regulate temperature, ventilation, and fixing smart locks. Interconnected clinical information systems such as Laboratory Information Systems ensure smart patient care processes. Moreover, identification systems enable authentication and tracking of patients, staff, and hospital equipment [48].

Teleconsultation and remote patient monitoring

The ample opportunities for effective communication resulting from technological advancements have laid the groundwork to enable real-time consultations between health providers and patients separated by geographical distance, a process known as teleconsultation and thus bridging the communication gap between them. A more robust form of teleconsultation is remote patient monitoring (RPM) which deploys the latest IT tools to provide diagnostic and treatment services to

Al Muammar et al. Int Arch Public Health Community Med 2018, 2:015

• Page 3 of 8 •

the patients located in remote and rural areas [49]. For instance, Alentejo, an underserved region in Portugal with regard to adequate and accessible health care, successfully initiated telemedicine and teleconsultation in 1998 as a means to improve healthcare and is now an essential part of service delivery there [50]. Moreover, a systematic review highlighted the feasibility of telemedicine in the field of dentistry for remote screening, diagnosis, and consultation [51]. Additionally, teleconsultations with the health provider have been found to enrich patient satisfaction due to improved outcomes, ease of use, low cost, better communication and reduced travel time [52]. Furthermore, studies have underlined strong support in favor of telemedicine in the aspect of patient safety since it has been revealed that use of telemedicine for consultation brought down the number of medical errors in between clinical visits, besides playing a part in lowering medication errors [53]. As excessive waiting time at the hospital continues to be a pressing problem faced by patients [54], the efficiency of e-consultations to provide convenient access to healthcare professionals may be considered.

Web as the source of health information

With the access to the internet reaching a crescendo, approximately eight out of ten Americans use the web as a source of health-related information [55]. This has cracked open an unlimited world of information for a digital age patient. Online medical encyclopedia's such as MedlinePlus provides comprehensive information regarding diseases, tests, symptoms, and treatment [56]. Help-seeking behavior using online information regarding mental health issues is on the rise among young adults [57].

Webinars

Online seminars, referred to as "webinars" offer patients an opportunity to virtually attend seminars presented by healthcare professionals from any location regarding various topics related to health and wellness. This enables them to gain more information related to aspects of self-care through audio-video feeds, slide images and allows them to interact with the presenter by asking queries [58].

Wearable sensors

Miniaturized, sensor-enabled wearable devices have made it plausible for patients with chronic diseases such as cardiovascular disease [59] and diabetes [60] to monitor their vital signs such as blood pressure and blood glucose level and thus indulge in self-care. It further allows the patient to transfer the data obtained to a health care professional using wireless technology. A review highlighted the feasibility of wearable devices in the promotion of physical activity and weight loss [61]. Moreover, the data obtained from the wearable sensors alert the patient and the healthcare team regarding adverse events and prompts timely remedial action [62].

Insideable devices

Unlike wearable sensors which usually remain in contact with the skin, ingestible sensors gauge the internal changes in homeostatic imbalance and offer novel means to diagnose and monitor the human body [63]. An ingestible sensor has been approved to monitor medication compliance among patients with hypertension and heart failure [64].

Another novel technique of monitoring is by way of implantable sensors which can be positioned below the skin and permits the measurement of vital signs, for example, Cardio MEMS is an implantable device which helps in continuously monitoring pulmonary artery pressure and a randomized clinical trial revealed a reduction in hospitalization of patients with chronic heart failure by 50% when their daily pressures were monitored [65].

Mobile apps

Smartphones with inbuilt health apps provide a unique opportunity for patient engagement by promoting, adopting and maintaining healthy behaviors [66]. As of 2015, approximately 165,000 health-related apps are available [67] and are broadly classified as 'wellness management apps' which assist in modifying behaviors related to lifestyle, diet, fitness etc. and 'health condition management' apps which facilitate dealing with disease conditions by providing information about the disease, access to care and medication reminders [68]. Chronic conditions including mental health conditions, diabetes, cardiovascular diseases, nervous system disorders and musculoskeletal conditions are amongst the most common conditions focused on health condition management apps [68]. Reassuringly, digital health apps have recently witnessed a substantial growth in their evidence-based efficacy with as many as 234 randomized controlled trials and 20 meta-analysis studies conducted [68].

Electronic Medical Records (EMR)

EMR's which can store health and medical information of a patient in digital form have widely attracted physicians; for instance, in Canada, approximately 75% of physicians have shifted to EMR use [69]. Besides improving the communication between the health care team, it delivers them readable and organized information which reduces the risk of medical errors [70].

Health portals

Aimed at bridging the communication gap between the patient and providers, portals are personal healthcare-related websites that allow the patients to communicate with their healthcare team through teleconsultations. Moreover, they permit access to lab test results, schedule appointments with the doctors and refill prescriptions [71,72]. A systematic review of the effect of patient portals concluded that ten out of

twenty-seven studies reported positive effects in terms of medication adherence, self-care practices, improved patient satisfaction [73]; and functional status [74].

Big data

As a result of the digitalization of medical and health records (EMR's) and data generated from wearable devices, a large and complex volume of data is being produced known as Big Data. This massive reservoir of information is now being put to use by assisting clinicians in providing an observational evidence base. Big Data has also facilitated the opportunity to deliver personalized treatment by using analytics in assimilating genomics with EMR [75].

The human genome project

By far the most monumental scientific discovery in recent times was the unraveling of information regarding the structure, organization and function of the human genome undertaken by an international research collaboration known as the Human Genome Project [76]. This project was an epitome of a partnership between biologists, and technologists since the investigation into the genome applied computing technology extensively and these days owing to further advances in biomedical technology, a sea change in the diagnosis and treatment of diseases is anticipated [77].

Personalized and precision medicine

As a result of advancements made through the Human Genome Project in understanding a person's genetic makeup which determines their susceptibility to certain diseases, it is now possible to provide tailored therapies suitable for each patient, thereby making them safer and effective. Personalized medicine takes into account not just the genetic makeup of individuals but also their preferences, beliefs, attitudes, knowledge and social context. On the other hand, precision medicine utilizes patient centrism, engagement, digital health application, genomics, molecular technologies and data sharing in health care delivery [78].

3D Printing

3D printing refers to the "deposition of materials such as plastic, metal, ceramics, powders, liquids or living cells in layers to produce a 3D object" [79]. It is redesigning healthcare since it is now possible to recreate body parts such as personalized prosthetics [79]. Remarkably, Spanish scientists have successfully launched a prototype for a 3D bioprinter that can create a fully functional human skin and can be transplanted to burn victims [80].

Artificial intelligence in healthcare

An exciting dimension to the digitalization of health care is the development of intelligent machines which exhibit cognitive actions analogous to human beings and are capable of conducting real-time analytics using algorithms [81]. For instance, IBM Watson helps clinicians make decisions by using natural language capabilities, hypothesis generation, and evidence-based learning. This is particularly useful given the surge in Big
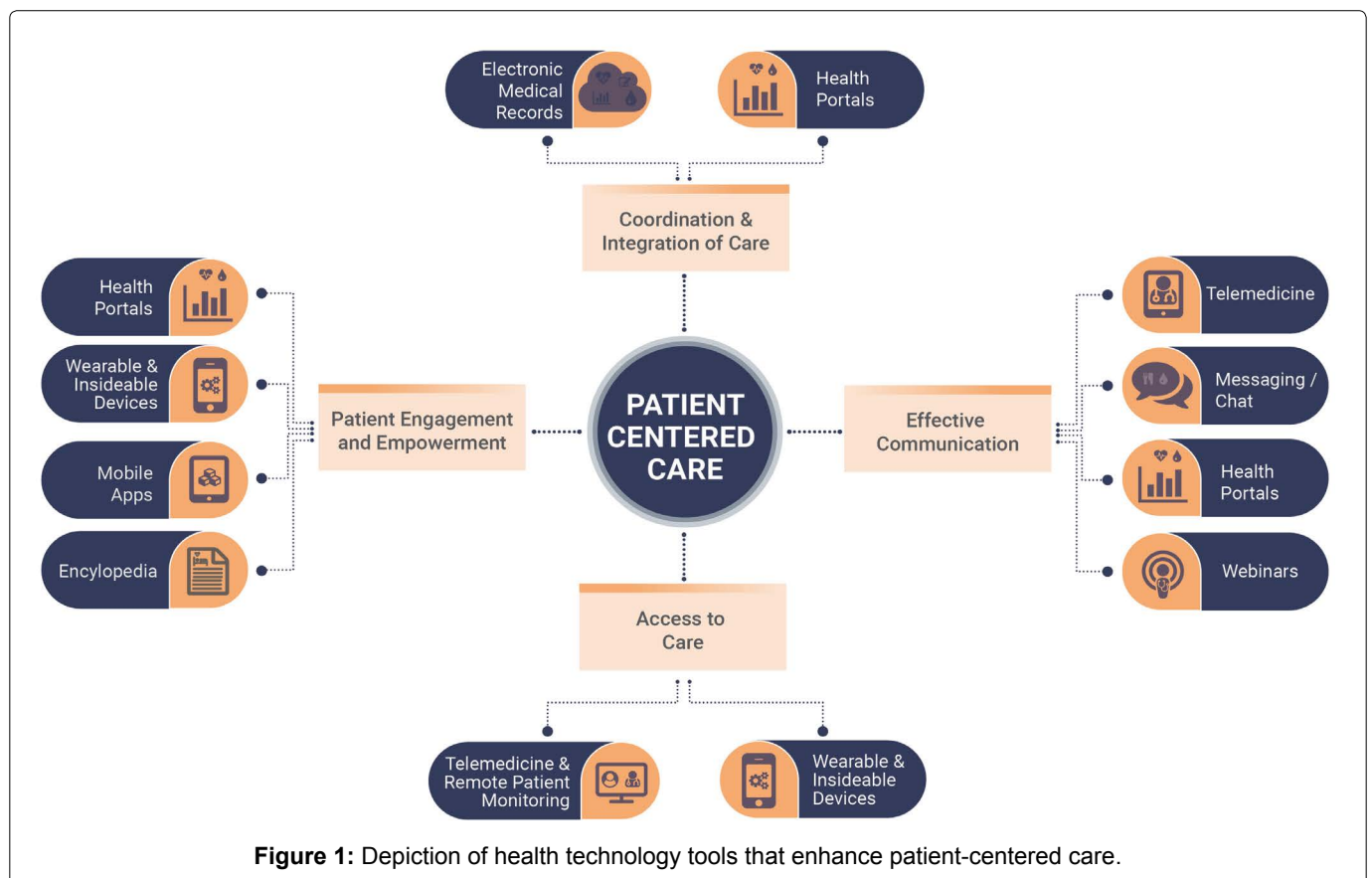

Figure 1: Depiction of health technology tools that enhance patient-centered care.

Data and will assist in excavating information and aid the doctors in making quicker and precise diagnosis [82]. The potential role an artificial conversation agent or Chatbot which uses speech or textual methods to conduct a conversation is being explored in healthcare to provide assistance for behavior change in diabetes and obesity management [83]. Additionally, Babylon Health is a conversational health service provider which uses artificial intelligence to have consultations with doctors [84].

Critical Views on Digitalization of Healthcare

In addition to the evidence supporting the implementation of digital tools as categorically mentioned above, it is worth looking into some of the critical views in relation to the digitalization of the healthcare sector. There is concern regarding the privacy and confidentiality of the patient's electronic medical records and system interoperability [85]. Correspondingly, it has been illustrated that EMR use has augmented the workload of the physicians which could lead to incidents of medical errors [86]. Ironically, where digital health claims to promote greater patient-provider interaction, it is argued that the presence of a computer between the two parties may prove to have a reverse effect [87]. Moreover, regular power blackouts and loss of internet connectivity is an often encountered barrier to the implementation of digital health, especially in developing countries [88]. Another cause for alarm is the ocean of health information available on the internet and how any unreliable information can lead to adverse health effects [89]. In addition, despite a gradual rise in the body of evidence surrounding digital health tools, there remains scope for more especially the evidence that can guide the scale-up of mHealth [90] likewise, the regulations that oversee technology use in healthcare have not kept pace with the swift advancements made in the technology arena [91].

Conclusion

Undoubtedly, the road to achieving quality, equitable, accessible and affordable healthcare for all sections of the populations is laid with numerous hurdles, even so, not all is lost. The paradigm shift in healthcare delivery towards patient-centered care has restructured the dynamics of the relationship between the patient and the provider and is allowing patients to play a vigorous role in safeguarding their own health. Furthermore, as the information and communication technology sector revels in several cutting-edge innovations with gadgets like smartphones and tablets becoming increasingly available to common man and providing an innovative means to uphold patient-centric values, it became imperative for the health sector to exploit the benefits of this resource leading to the digitalization of the health sector and driving the momentum towards improving health and wellbeing of the people. Notwithstanding the criticism surrounding the use of technology in healthcare, the benefits far outweigh the challenges and digitalized health continues to flourish. Although this area of health care is in its nascent stages given that embracing it has been snail-paced and has a long way to go in its implementation, building up its evidence base and developing a regulatory framework, an enthusiasm is brewing in view of its unprecedented potential in disease treatment, disease prevention and promotion of health. It has the ability to reach out to every person, at every stratum in need of healthcare and may thus prove to be a silver lining in the healthcare system.

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Al Muammar et al. Int Arch Public Health Community Med 2018, 2:015

• Page 6 of 8 •

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