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High-Value Health System for All: Technologies for Promoting Health Education and Awareness

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***Abstract*—**Health for all is considered as a sign of well-being and inclusive growth. New healthcare technologies are contributing to the quality of human lives by promoting health education and awareness, leading to the prevention, early diagnosis and treatment of the symptoms of diseases. Healthcare technologies have now migrated from the medical and institutionalized settings to the home and everyday life. This paper explores these new technologies and investigates how they contribute to health education and awareness, promoting the objective of high-value health system for all. The methodology used for the research is literature review. The paper also discusses the opportunities and challenges with futuristic healthcare technologies. The combined advances in genomics medicine, wearables and the IoT with enhanced data collection in electronic health record (EHR) systems, environmental sensors, and mobile device applications can contribute in a big way to high-value health system for all. The promise by these technologies includes reduced total cost of healthcare, reduced incidence of medical diagnosis errors, and reduced treatment variability. The major barriers to adoption include concerns with security, privacy, and integrity of healthcare data, regulation and compliance issues, service reliability, interoperability and portability of data, and user friendliness and convenience of these technologies.

***Keywords*—**Bigdata, education, healthcare, ICT, patients, technologies.

I. Introduction

TECHNOLOGY is changing the way the information is accessed, communicated, analyzed and the way people think. New technologies including that of information communication technologies (ICT) are essentially contributing to the quality of our lives. These technologies play an important role in health education as they create opportunities for the diagnosis, treatment and prevention of diseases [1]. The OECD ministerial statement on the next generation Health Reforms' focus is on the following: (i) Promoting high-value health systems for all (ii) Adapting health systems to new technologies and innovation (iii) Reorienting health systems to become more people-centred and (iv) Encouraging dialogue and international co-operation [2]. Health for all is considered as a source of well-being and inclusive growth. Healthy (mentally and physically) people can contribute to human capital and can become active participants in our societies. A healthcare system can also be a potential trainer, employer, and contractor. So it would be interesting to explore how technologies can be harnessed to health education for promoting health for all, better patient experience, and lowering the overall costs.

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Technological advances can improve the quality and efficiency of healthcare practices and delivery. The wider reach and accessibility of the new technologies to health professionals, students, patients, families, and communities will facilitate interactions among all of them. This will allow incorporation of these diverse technologies into our daily lives. Health education in schools builds students' knowledge, skills, and positive attitudes about physical, mental, emotional and social health. Studies have shown that healthier students tend to do better in schools with higher attendance and better grades [3].

Healthcare technologies have undergone many transitions such as migration from institutionalized settings to the home and everyday life, conventional medical care getting replaced with self-care, etc. Trained nurses are getting replaced with untrained patients and caregivers, and organized medical wards getting replaced with the cluttered homes. In order to promote the sustained use of healthcare technologies, researchers and designers explored the potential of employing serious games, gamification, and other playful and engaging approaches to make healthcare a more playful activity for all users from mainstream to children, teenagers, and older adults [4].

The existing healthcare systems need a reorientation promoting the physical and mental health with patient focus and continuous care [3]. Health technologies such as genomics, ICT tools, health analytics and big data provide a wide range of treatment possibilities but they may have significant budget impact. The new technologies are being introduced at a much faster pace than they could be harnessed effectively by the educators, caregivers, and the public. These include tablets to smart phone technologies and watches and from physical activity trackers to 3D printers. Leveraging the technological resources for improving health education and clinical practices is a big opportunity.

II. Literature Review

This section begins with the discussion on how updated knowledge is important in primary healthcare. Reference [5] proposes a three-part continuing educational model for primary health care professionals (ConPrim) to fill the gap between existing knowledge and the application of this knowledge in practice. ConPrim is a promising model for continuing educational interventions in primary health care. It includes a web-based program, a practical exercise and a case seminar.

Reference [6] explores the potential of bringing innovations

in public health education by drawing insights from the specialized disciplines of economics, policy and management for their applications in the health sector. This includes a departmental health policy network (HPN), activities to foster long-term industry linkages, and interaction opportunities with related programmes in international universities, both from developing and developed countries [6]. Reference [7] suggests that inter professional education (IPE) can be themed as part of a curriculum that can be integrated into clinical condition or social need teachings, considering how care is supported by professionals, volunteers and family members. In this way, a horizontal element gets integrated into a range of learning modules or courses across the professional years, integrating the exposure, immersion and mastery.

Patients suffering from chronic illnesses need daily care and follow-up. Occasional visits to healthcare providers may not be sufficient for them and they must be empowered to monitor and manage their own health [8]. In order to best execute self-care, patients must be provided with the tools to better communicate with their healthcare providers. A nationwide EHR system has the potential to reduce healthcare errors, inefficiencies, and unnecessary costs, thus allowing for better quality of care [8]. The technological advances can be extended to the field of HIV self-management also. Consideration of these aspects are important to inform the design of future programs for facilitating self-management among people live with HIV, and to inform the application of ICT platforms for HIV treatment and intervention [9]. The major concern here is of privacy. In the context of HIV/AIDS, ICTs have mediated interventions directed at preventing the transmission of the virus or monitoring patients by promoting improved accessibility and quality of care [10].

Using ICTs in physical education (PE) can promote student's motivation to exercise independently in leisure time [11]. Consequently, PE teachers can adopt the study design as a recommendation for conducting a teaching program that includes learning and improving aerobic ability in long-distance runs as well. A truly positive note is that PE lessons can improve abilities, improve perceptions of abilities, and instill habits for a healthy and active lifestyle, by employing teaching approaches that emphasize a combination of various psychological aspects that can help to instill motivation to participate in the teaching program [11].

Increased price transparency of medications in dermatology is an important requirement today. New developments in information systems allow physicians to take cost conscious clinical decision making [12]. Reference [13] investigates how the patients make healthcare decisions if they use mobile phones during an illness. Based on the original survey data from India and China, the authors have discovered that even though the mobile phones are positively contributing to the healthcare access, the health-related phone use was delaying the access to the physicians and hospitals.

Previous researches have established that high ICT use is associated with higher levels of anxiety, depression, and overall psychological distress. However, [14] suggests that there is a real (if small) emotional buffering effect afforded by ICTs. Experimental results indicated that the mobile phone may offer a small "security blanket" effect, lowering the initial negative reaction to stress. This could be a short-lived effect and people may end up turning to ICT use as an emotional avoidance strategy in a more frequent pattern which may lead to or exacerbate mental health problems in the long run [14].

Innovative diagnostics for better patient care across diverse clinical settings is known as point-of-care technologies (POCT) [15]. The National Heart, Lung, and Blood Institute convened working group recently reviewed [15] the state of the POCT field, discussed the opportunities for POCT to improve cardiovascular care, and examined the barriers facing translation and integration of POCT with existing clinical systems.

Reference [16] proposes that genetic distance (i.e., long term cultural and biological divergence) to the health frontier influences population health outcomes. It is interpreted that genetic distance is related to population health indirectly through human barriers to the diffusion of modern health technologies. Their study based on a world sample has identified genetic distance as an important factor determining the country wise health inequalities. Their evidence also indicates that the gene gradient emerges at the onset of the international epidemiological transition [16].

Consumer health technologies (CHT) can empower healthcare consumers to take a proactive role in managing their health and related costs. Reference [17] investigates how user profiles and personas are used for developing CHT devices for old-age people. The rising health care cost concerns of today are mainly because of the "graying of the globe." The worldwide population of adults over 65 years of age is on the rise and expected to reach 761 million by 2025 [17].

The use of ICTs is universally acknowledged as a useful resource for improving the quality of life of the elderly, allowing them a more independent lifestyle that promotes active ageing, personal relationships and labor and social participation. However, in order for these elderly individuals to take advantage of ICTs, training programs may be needed, since there is a digital divide existing in this generation which depends on the access available to telecommunications, economic wealth and social development [18]. It exists both in developed and developing countries, and also in places where a division exists between the urban and the rural, rich and poor, the more and less educated, men and women and youth and the elderly.

In the belief that knowledge is power, [19] explores whether an understanding of how technology works and access to certain technologies can empower senior citizens to gain more control over their personal well-being and overcome the problem of social exclusion. They discuss the social impacts of emerging technologies like augmented reality and virtual reality. Reference [20] explores the influences of ICT and its impact to the quality of life and subjective health of the elderly. Even though these technologies are empowering them by compensating their functional disabilities and increasing their safety, the resulting remote-communication can lead to

reduced in-person communication and increased social exclusion [20].

Reference [21] analyzed publications presenting the service layer of health-enabling technologies for elderly people. This analysis led to six archetypical categories of services for elderly people based on health-enabling technologies. The focus of the analyzed projects lay on two categories, namely handling adverse conditions and assessing the state of health. Assistive technologies and sensors in the home environment can increase the sense of safety and security at home [22]. This could be true with bodily worn systems that also monitor people's movement. However, their use raises ethical anxieties as little is known about how older persons perceive assistive and monitoring technologies. Barriers to the adoption of assistive technologies (ATs) include privacy, trust, functionality/added value, cost, ease of use and sustainability for daily use, perception of no need, stigma and fear of dependence [22].

It is interesting to note that when we think about the future for older adults we are in essence thinking about our own futures. We can envision a situation where older adults have autonomy and independence, can easily manage their health and wellness needs, have good opportunities for social connectedness, personal growth, continued life purpose, and overall high quality of life [23]. To attain this futuristic requirement, we must be acting now. These technologies need to be designed with involvement of today's older adults who represent the needs and capabilities of tomorrow's older adults.

There must be policies for building the necessary infrastructure for deploying these technologies with adaptive functionality to support the changing needs and preferences of individuals in such a way that they are available to everyone and they must be integrated into people's lives at younger ages [23].

Fall prevention within the home environment has been a topic of research for over three decades and is recognized as an important health issue within the United Kingdom (UK), Europe, North America and Australia [24]. In recent years, many technology-based applications have been developed with the goal of assisting in the delivery of more effective and efficient fall prevention interventions. Reference [24] presents a conceptual framework and survey of the state of the art of technology-based fall prevention systems which is derived from a systematic template analysis of studies presented in contemporary research literature.

Health smart homes (HSH) and home-based consumer health (HCH) technologies are potential solutions to support older adults to age in place – the ability to live in a residence of their choice without moving as their needs for health care services change [25]. Home healthcare technologies are mainly used for monitoring activities of cognitive decline, mental health, and heart conditions in older adults with complex needs [26]. However, the technology readiness for smart homes and home healthcare technologies is still on the lower side. Home health provisioning systems (HHPS) have been argued to represent the best as well as the worst systems of the healthcare delivery in developed nations such as the United States. The HHPS represents an arrangement where physicians provide routine, emergent, as well as enhanced healthcare services; at the patient's home both for the patient's convenience at a supplemental fee [27].

Wearable technology is undergoing exciting developments that could impact and disrupt many technologies for healthcare provision and education. Current practical and potential uses of this technology in healthcare (especially in patient monitoring and data reporting) and medical education indicate, as highlighted in this article, that a new era of interaction between people and technology is about to begin that could ultimately translate into our ability to provide healthcare systems that are more efficient and responsive than the current ones [28]. Cloud computing can reduce the start-up expenses of implementing EHRs. The wide usage of smartphones and cloud computing allows ubiquitous and affordable access to the health data by authorized persons, including patients and doctors [29]. However, many of the healthcare institutions are yet to implement cloud computing due to the associated privacy and security issues.

During the past decade, the intensive use of health information technology (HIT) has generated enormous variety of patient data that come from medical recordings (e.g., EHR; biomedical data), as well as external data sources, such as insurance claims/billing, R&D laboratories, and social media [30]. This big data empower the medical institutions to have valuable insights and facilitate timely decision-making, minimize patient risk, and reduce clinical cost. Internet of Things (IoT) opens up many opportunities for smart and connected healthcare. IoT allows a paradigm shift in the practice of medicine from the current post facto diagnoses and reactive treatment to a proactive prognosis of diseases together with prevention and cure [31]. It also enables personalization of treatment and management options targeted particularly to the specific circumstances and needs of the individual, and helps reduce the cost of healthcare while simultaneously improving outcomes.

III. Futuristic Healthcare Technologies

The growth of IoT will allow attachable, carriable, implantable and wearable healthcare sensors and devices to form body and home networks [32]. Precision medicine is another emerging approach for disease diagnosis, treatment and prevention that takes into account individual variability in genes, physiology, environmental exposures and lifestyle [32]. It combines advances in genomics medicine, wearables and the IoT with enhanced data collection in EHR systems, environmental sensors, wearables and mobile device applications. It needs the data surrounding patient history, physical exam and routine laboratory studies to which genomic sequencing and microbiomic (skin, respiratory tract and intestinal bacteria) sampling added. The wearables include smart watches, head-mounted displays (HMDs), body-worn cameras, Bluetooth headsets, wristbands, smart garments, sports watches and other fitness trackers.

Digital clinical encounters [32] are semi-automated by

using a protocolized computer program to facilitate history taking, diagnosis, prescribing and documentation, leveraging clinical algorithms and evidence-based clinical knowledge to minimize clinicians' direct involvement prior to their review and consent. The result is a diagnosis and a recommended treatment plan that a clinician can quickly review, modify when necessary and approve which is stored in the clinician's EHR. The transformational systems [32] can substantially increase both patient and clinician satisfaction, and deliver high quality care. These keep patients away from unnecessary emergency room visits and can improve access for encounters that require in-person visits.

Patient decision aids [32] are complex interactive systems based on computational logic that helps individuals/patients to make better-informed health decisions. They may cover triage, diagnostic and treatment options, end-of-life choices, and eventual first-pass genetic counseling. Personal analytics [32] is the use of data by an individual to help achieve objectives across a range of domains. These include personal healthcare, safety, financial management, employment, social connection, self-esteem, and self-actualization. Healthcare consumer persuasion analytics [32] utilizes patient and consumer clinical, experiential, social/environmental, and behavioral data to derive and understand key motivators and influencers of individual health behaviors and outcomes. This is useful for population health management, personalized health promotion /decision aids and precision marketing.

Generation 2 medical shopping [32] is distinct from its predecessor in providing additional capabilities such as virtual care, retail facilities, connection with appointment scheduling and provider payment. It provides improved coordination with related parts of the consumer experience. In-vehicle health monitoring [32] refers to sensors, applications and algorithms that can measure the biophysical attributes of drivers and other vehicle occupants with technology embedded in the vehicle. The seats may be measuring the heart rates, and the steering wheels may be analyzing perspiration levels to determine dehydration levels. The above information needs to be communicated wirelessly to healthcare providers, family members and other concerned parties. Wearable devices can also provide health information in an in-vehicle situation.

Personal health-tracking devices [32] such as weight scales, personal health scanners, and blood pressure and sugar monitors help users monitor their health in their home or on the go, possibly round the clock. These may be linked to a mobile app and a cloud service with the option to share the personal health information with their doctor or physician depending on their personal preferences. Eldercare-assistive robots [32] are smart machines designed to help human patient /caregiver clients. It can provide physician support, psychological support (motivation, companionship), and healthcare delivery services/therapeutic support for observations, monitoring, coaching or emergency action. Medication compliance management systems [32] are designed to remind and monitor patients to take their medications, and also to send alerts to patients, doctors, nurses or family members.

Personal health management tools (PHMTs) allow individuals to establish programs to track diet, exercise and routine care, and to monitor typical chronic illnesses, such as asthma and diabetes [32]. Personal wellness records (PWRs) are platforms that allow consumers to aggregate data from wellness apps and devices from different businesses, and to share the data with other apps, devices, enterprise applications, caregivers or clinicians [32] for use by the consumer. On-demand virtual visit systems [32] need to have remote healthcare connections by the patient with a network of clinicians, round the clock.

3D bioprinting systems [33] produce living tissue "products" functioning like human organs such as kidneys, livers or other organs for transplant. Genomics medicine [33] is a breakthrough model for medical science (and other fields) triggered by the mapping of the human genome, which includes sequencing of biological specimens, genetic results storage, analysis of genetic data, and recommendations for care and bioinformatics for traditional R&D as well as for medical practice. The new generation Healthcare ERP [33] solutions are priced, delivered and managed via cloud services. Healthcare enterprise CRM/contact center systems [33] are software applications that combine inbound/ outbound call center/patient access service management which are complementary to the patient scheduling, check-in/check-out and admitting/discharge/transfer functions found in patient administration systems, physician practice management systems and integrated healthcare EHR megasuites.

Real-time hospital operations dashboards [33] are decision management tools to synthesize and contextualize a variety of current operations and clinical data, with the objective of standardization and mastery of operations, and also adapting to unpredictable demand by integrating the perspective among siloed settings and roles. This allows more unified operation and adjustment using business intelligence/big data platforms, in-memory computing, predictive algorithms, complex-event processing and advanced visualization.

The U.S. provider population health analytics (PPHA) is a set of provider-led analytics capabilities supporting population health management, including risk stratification, patient cohorting and disease registry development, care gap analysis, care coordination, and management workflow [33]. It is expected to integrate claims and EHR data, and incorporate advanced analytics and predictive modeling to discern patterns and correlations among patient risk factors, diagnoses/ diseases, treatment approaches and outcomes. Generation 3 EHRs [33] are sophisticated clinical software systems for acute care (medical or surgical wards, emergency, intensive care unit, surgical theaters, and labor and delivery suites) and for ambulatory or outpatient clinics, which contain patient-centric, electronically maintained information about an individual's health status and care; focus on tasks and events directly related to patient care; facilitate and enable clinical pathways; enable the practice of evidence-based medicine; and are optimized for use by all clinicians.

IV. Discussion

Electronic healthcare technologies are extensively used by patients, doctors, and other healthcare professionals, essentially to decrease healthcare costs and provide efficient healthcare processes. These technologies play an important role in health education as it relates to the prevention, early diagnosis and treatment of the symptoms of the diseases. This transformation should yield significantly reduced incidence of medical diagnosis error, reduction in treatment variability, and ultimately, reduced total cost of care [32]. The major concern in the extensive use of these technologies is with security, privacy, and integrity of healthcare data. Several solutions have been proposed to address these issues [34]. The other important concerns are with respect to regulation and compliance, service reliability, interoperability and portability, diagnosis error, treatment variability, and reduced overall costs of care. Concerns are also due to user friendliness and convenience of these technologies.

It may take years to develop the technology to capture all the data elements needed for healthcare technology advancements and to standardize their recording and analysis. Barriers to adoption of the above technologies include concerns about accuracy, legal risks, payments and cultural acceptance. Factors that are inhibiting this market include questions regarding the content and its delivery. The current technical limitation of interoperability may hinder advancement of many of these tools. There is also uncertainty regarding whether patients will accept and use these systems. There could be difficulties in accessing the patient's full medical records due to technical issues that may make follow-up care inaccurate. Disruption to the provider's workflow, alarm to patients and lack of evidence of value to patients are also concerns.

One main contributing factor in the adoption of the future technologies could be the progress on the life science front [33]. Realism about the value consumers and businesses perceive in new wearable devices is a major concern. New apps and algorithms may be needed to fully interpret the inputs from wearable sensors, and integrate the data with other software platforms and IoT to deliver timely, accurate and more actionable advice, remote control and monitoring [32]. The accuracy and consistency of online medical information and resources will continue to be a challenge. Also, at present, the consumers are getting very little assistance and advice in weighing the legitimacy of online medical education.

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