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The Role of Health Technology in Transforming Healthcare Delivery and Enhancing Spending Efficiency

Ziyad S. Almalki[1]*, Duaa A. Simsim[2]

Abstract— **Objectives:** Advances in technology are changing the way healthcare services are delivered. The adoption of different health technologies has significantly improved health access and efficiency. In addition, health-technology adoption can help immensely in improving health outcomes and enhancing public and private healthcare spending efficiency. However, the role of health technology in transforming healthcare delivery and enhancing spending efficiency is not well understood. In this paper, we reviewed the role of emerging technologies in delivering health services that promote health outcomes, improve productivity of the healthcare provider, and reduce healthcare costs. **Methods:** A narrative review was conducted of published articles as well as grey literature on application of technology in delivering medical care. Studies that met the following criteria were included: addressed a relevant aspect of technology in healthcare delivery; written in English; published between 1994 and June 2020; qualitative and quantitative study designs, systematic reviews, and primary and secondary research. **Main results and conclusions:** Utilizing technologies in delivering health services showed promise in improving health outcomes, enhancing healthcare productivity, and reducing overall healthcare costs. However, before these technologies are implemented, reimbursement and equity are two main issues that need to be addressed.

Keywords: Healthcare Services, Economic Benefits, Equity, Healthcare Delivery, Healthcare Costs

1. INTRODUCTION

Around six months have passed since the emergence of an ongoing coronavirus-related pandemic. There is nothing like a worldwide pandemic to force people to shift gears. COVID-19 has impacted nearly every aspect of our lives, and nowhere is that more evident than in the healthcare arena [1]. Emergency medical staff from all over the world in the hardest-hit areas are working around the clock to care for patients infected by the virus. While global healthcare services are planning for an increase in COVID-19 cases, immediate action is needed to improve healthcare and expand our systems through digital technologies.

A lot of countries adopted these technologies in their healthcare system decades ago. Such transitions are influenced by the fact that expenses need to be reduced (or at least their growth restricted) in high-income countries, while inadequate affordability and level of care are the catalysts in low-income countries [2]. In healthcare delivery, we are beginning to see many practices shifting to use technology to deliver care more noticeably than ever to reduce the risk of spreading COVID-19 to patients and staff, as well as to extend coverage to understaffed areas.

A number of factors, such as geographic distance, weather, lack of public transportation, and provider shortages, can impede access to in-person care. Improving and increasing the use of existing health services can be carried out by extending the approach to the remote-care system using advanced technology [3]. There are several examples of programs that demonstrate the potential for better access to care. For instance, personal health records systems are not just static medical data repositories; they incorporate data, information, and technological resources that allow patients to become actively involved in their healthcare [4]. Patients with access to personal health records and who can use e-mail or online resources instead of visiting a clinic can support remote and interactive communications with providers, thus enhancing their access to healthcare [5,6]. Another example is the popular Videoconference Cognitive Behavioral Technique (VCBT), which has the ability to make advanced services more available to patients with obsessive-compulsive disorder (OCD), panic disorder (PD), and social anxiety disorder (SAD) [7]. In addition, teledermatology was adequate to treat 77 percent of the patients in 11 underserved primary care clinics in Philadelphia, and at least 61 percent of the referral patients would otherwise not have received dermatological treatment [8].

Lack of service means no physical access; it means virtual direct connections through communication technology for many needs. The health insurance fund in Estonia allows the usage of technology for some hospital services, such as

[1]Department of Clinical Pharmacy, College of Pharmacy, Prince Sattam Bin Abdulaziz University, Al-Kharj, Riyadh, Saudi Arabia.
[2]Pharmaceutical Services Department, Alawi Tunsi Hospital, Makkah, Saudi Arabia.
*Corresponding Author: Ziyad S. Almalki, PhD.
Email address: z.almalki@psau.edu.sa

specialist consultations, physiotherapy, and mental health nurse consultations to be provided remotely with timely and high-quality medical care, paying for them using the standard tariff [9]. In Ireland, general practitioners (GPs) are enabled to conduct remote consultations for all conditions, and the fee will be payable to GPs [10]. Several other countries, such as Germany, Luxembourg, Netherlands, and Slovakia, have expanded the scope of services for non-COVID-19 care to take place by telephone or other remote means [11]. Such methods can ideally help to minimize the pressure by mitigating unpreventable income loss while ensuring that the pandemic and other forthcoming emergencies are adequately prepared for.

The application of technology in delivering medical care has proved that it facilitates improved control of long-term treatment and patient satisfaction and provides innovative ways to find and connect with healthcare personnel, thereby enhancing patient safety and reducing future transportation demands, for both physicians and patients [12]. Web-based disease management systems encourage the patient to take an active role in self-management, help physicians to care for patients sooner, offer local and cheaper services, expand scarce healthcare resources, improve monitoring, enhance patient access, and improve the quality and accuracy of patients' medical records [13].

In terms of value-based healthcare, in most countries, healthcare expenditure has increased at rates greater than the gross domestic product (GDP). In 2017, the United Kingdom paid approximately $2,989 per person for health services, approximately the median for Organisation for Economic Co-operation and Development (OECD) members ($3,280 per person). The countries in the G7 with the largest health expenditure, however, were France ($4,194), Germany ($4,974) and the United States ($8,682) [14]. In 2020, healthcare spending in the United States rose to about US$4 trillion (18.6 per cent) in GDP overall [15]. The key drivers identified for increased health spending are including population ageing; increased public demand and desires; growth in income earned; increasing costs for medical care and hospital services (e.g., labor costs); and organization shortfalls and care reimbursements [16]. For instance, life expectancy growth has had a strong and progressive effect on health demand. In most nations, increasing health costs are seen as a lasting obstacle, and a dynamic combination of cost management, affordable and equal access to treatment, and modern technologies.

In any healthcare system, there are two ways to reduce costs: use fewer services and increase productivity. The healthcare systems in most countries have largely focused on using fewer services through improving patients' health outcomes. On the one hand, this is appropriate because the industry overuses many services, and some are harmful. On the other hand, few countries solved their cost problems by simply improving healthcare productivity. Therefore, there is continuing interest from academics, clinicians, and policy makers about the value of technologies in healthcare delivery for improving health outcomes and enhancing healthcare productivity, and about whether these technologies may actually reduce overall costs by replacing the current model of care delivery [17]. This article reviewed these aspects of the connection between new healthcare technology and lower cost. First, we discuss technology's potential to enhance health outcomes. Second, we examine how these technologies could be a primary driver to enhance healthcare productivity. Third, we review data on the contribution of healthcare technologies to the lowering of direct healthcare costs. Finally, we comment on the main considerations that should be addressed when implementing and evaluating technologies to achieve a more cost-effective embracing of technology in healthcare delivery.

2. METHODS

This literature review was carried out to explore the types of technologies used within healthcare delivery, their potential to enhance health outcomes and healthcare productivity, and lower healthcare costs. Three databases were used to conduct the search for literature: Web of Science, PubMed and Google Scholar. The Boolean search operator 'AND' was used to combine the search term 'healthcare delivery' with the following terms: 'technology', 'mobile technology', 'electronic-health', 'mobile-health', 'virtual reality', 'electronic health records', 'e-prescribing', 'patients' personal health records', 'productivity', 'efficiency', and 'telemedicine', and 'remote monitoring'. These search terms were applied to the abstract field across all three databases. Studies that met the following criteria were included: addressed a relevant aspect of technology in healthcare delivery; written in English; published between 1994 and June 2020; qualitative and quantitative study designs, systematic reviews, and primary and secondary research. Literature was excluded for the following reasons: not focused on the use of technology in healthcare delivery; or not written in English. References in the articles found were also searched for additional articles, as well as articles citing the included papers.

3. RESULTS

3.1 Healthcare delivery technologies outcome

Healthcare delivery technologies are a vast collection of apps, processes, and resources that collect information that enables delivery of care. The literature suggests that these technologies can reduce medication errors, hospital admissions, length of stay, and mortality, and can improve patients' adherence to treatment plans. The application of this technology has resulted in a substantial decrease in prescription errors and in adverse reactions in hospitals, according to a meta-analysis of the efficacy of electronic patient instructions [18]. An even retrospective study found that telemonitoring systems are effective for enhancing active disease prevention in extremely vulnerable patients and therefore avoiding rehospitalization or visits to the emergency room [19]. Furthermore, a literature review of the nature and extent of telemonitoring outcomes showed the positive effects of telemonitoring in clinical outcomes (e.g., reduction in emergency room visits, admission to hospital, and mean length of hospitalization) [20].

In several studies, these techniques are shown to be more convenient for people in treatment and thus have been more effective in improving drug adherence and thereby reducing

further complications in the longer term. For example, another systematic review conducted to evaluate the impact of telemedicine interventions on pharmacologic adherence found that telemedicine can improve adherence to medication in patients with depression, bipolar disorder, and/or schizophrenia [21]. Ramsey et al and colleagues [22] systematically review published research on digital interventions, such as electronic monitoring systems, web-reported communication with the healthcare staff, and reminder text messages. In addition to the effectiveness in enhancing medication adherence, these technologies have also been shown to enhance health outcomes.

3.2 Enhanced healthcare productivity

There is a global consensus that healthcare's use of digital technologies is at least a decade behind many other sectors. Compared to other areas, it can be far behind recognizing the improvements in productivity and value afforded by technology. The healthcare industry has experienced declines in productivity despite spending enormously on technology. In addition, healthcare costs continue to increase faster than the GDP, impacting the budgets of federal, state, and city governments, employers, and individuals. Economic models suggest that if healthcare productivity could grow by 4 percent, we would solve the healthcare cost problem. To meet the growing demands in healthcare services, it is important to improve healthcare productivity via utilization of healthcare-delivery technology. Thus, the opportunities are not just to improve the health outcomes but also to improve the healthcare workers' productivity. In other words, productivity is the critical aspect of any economy's capacity to produce more for less (or the same expense at least). Increased productivity of healthcare services will allow medical advancements to continue to meet the increasing demand for services.

While there are no specific effectiveness indicators, technology can, however, improve health care efficiency and hence, the productivity of healthcare in various ways. For example, teledermatology has been developed to provide dermatological services (clinical and laboratory) to people living far from specialists in remote areas. Rather than seeing every patient in person, dermatologists were able to reach additional patients via the photographs and medical records stored and shared by referring physicians on the secure server. Studies showed that the number of annual consultations has increased by almost 68% after active teledermatology programs were adopted [23]. In another example, the association between electronic communication and workload of the patient / physician was explored in an extended analysis. The study found that Kaiser Permanente (KP) HealthConnect™ Online was associated with decreased rates of primary care visits [24]. The reduction in the rate of visits was 10.3%, or 0.25 visits per member per year (p < .001), compared to those in the period before the implementation of the system.

The implementation of these options means fewer patients in waiting rooms and less pressure on emergency departments; this saving will give doctors more time to examine complex situations and concentrate on clinical outcomes and patient satisfaction [25,26,27]. In addition, implementing these solutions could also fill the expected national shortage of health professionals [28].

3.3 Economic benefit

While using technology in delivering medical services can improve health outcomes and healthcare productivity, it is more likely to reduce healthcare costs, particularly in the long term. A new US report has revealed that travel and wait time for healthcare are higher than any other sector, contributing to lost opportunities costing providers $89 billion. Long wait times are facilitating the use of innovative services, for instance telemedicine, medical services, and on-site clinics offered by employers, to meet customers' needs, in particular those of the aged, and to provide a greater source of comfort [29]. In fact, another study reports cost savings in virtual health systems and depicts a saving in primary care doctors' time of over $7 billion annually [30].

Electronic communication between patients and their physicians has shown a significant reduction in total spending for insurance. In a new report, healthcare costs were reduced by $3.69 per member per month when patient and provider communicated electronically [31]. Furthermore, the interactive videoconferencing was investigated by O'Reilly et al. The researcher compared the clinical outcomes and cost between telepsychiatry and face-to-face psychiatric encounters involving 495 patients from the Thunder Bay region in Canada, a region with an inadequate number of psychiatrists. The findings showed that the cost of telepsychiatry was 10 percent below the cost of personal care per patient (16 percent lower per visit) [32]. Finally, in a pilot trial of remote monitoring (RM) of homebound heart failure (HF), patients hospitalized with HF at Massachusetts General Hospital were randomized to a control group (n = 68) or to a group that was offered RM (n = 82). The results have shown that RM of HF patients has already saved more than 10 million dollars over six years [33].

The cost-effectiveness of using technologies in healthcare delivery has also been analyzed in several studies using healthcare perspective. In 2014, Elbert et al [34] identified how digital health is cost-effective in the study of systematic reviews and meta-analysis of eHealth approaches to somatic diseases. In 2018, Sanyal et al [35] reviewed data in reports from 2010 to 2016 in another comprehensive review of the economic assessment of eHealth technology. The researchers noted that the majority of the randomized control method and predictive analysis that fulfilled the inclusion criterion demonstrated the cost-effectiveness of using eHealth technologies [36]. In addition, patients with chronic illness who used home-based monitoring systems show better health outcomes and overall healthcare savings [37].

3.4 Moving forward

We recognize that changing population trends, aging, and growing prevalence of chronic disease generate a tremendous need for medical services. Healthcare technologies in particular provide new opportunities for improved healthcare delivery, from prevention and enhancement of health to curative treatments and automated management. As such, they can reshape medical services to make a significant contribution to the objectives of the health system.

Although, technology that highly improves the outcome in one clinical scenario, it can have no effect in many situations. The results and outcomes of these technologies will depend in particular on the quality of the service and of the stakeholder groups, including professionals and caregivers, medical service production companies, and public authorities [38-39]. The scope and effect of these technologies will differ dramatically from case to case, emphasizing the difficulty of assessing their effect.

A thorough understanding of the two main interrelated variables, "the healthcare service" and "the digital," as well as a thorough consideration of the whole process of development, production, financing, implementation, and evaluation, is necessary for the development of the application of such technologies. If designed purposefully and cost-effectively, the innovative technology that some health services can deliver provides better health results and contributes to the sustainability of health systems. Those technologies should therefore be carefully evaluated and monitored in their introduction, implementation, use, and funding. The fact that new technology in healthcare, like other technologies, normally positively impacts certain strategic goals as well as certain groups while adversely affecting others, is underlined.

There are some considerations that should be addressed when implementing and evaluating technologies. First, a real challenge is to reimburse or fund a health service from the savings of a public healthcare system [40]. Although that would be fairly straightforward in countries with complete healthcare coverage, it is problematic for millions of unsecured patients worldwide. This may then be a starting point to make it easier for the uninsured to sign and governments to cover the bill for these patients [41]. Several other nations have been moving in that direction lately, and others could follow their example. Being flexible enough to simplify rules for payment of telemedicine, such as whether a practitioner can diagnose, treat, administer, and get reimbursed, can help. Whereas certain countries like the U.S. and Germany move quickly to simplify these regulations, many others restrict the use of telemedicine.

Second, equity is important to take into account in the implementation of these technologies in the context of the preferences or capacities of different groups of people. Some of the problems may also be variations in the use and comprehension of technology within age groups. We recognize that although digitization can lead to disparities in use in different age groups, companies could tailor a specific technology more directly to the needs of different age groups. Thus, it also should be used by explicitly vulnerable communities, including poor residents lacking access to health services or individuals with insufficient knowledge in healthcare.

4. CONCLUSION

The chronic health burden is steadily rising year after year, and the costs are significantly increasing. The use of technology to deliver healthcare would mitigate some of the costs linked to poor health by providing interventions that can help patients manage their chronic conditions or improve their health, thus reducing morbidity and mortality. In the current healthcare system, the patient must be given any kind of treatment or support at the medical facility. The application of technology for the delivery of care means carrying the care to the patient rather than the patient to the care. We believe that reimbursement and equity are two main issues that need to be addressed before implementing these technologies in order to make significant gains in health outcomes, productivity, and saving.

Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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