The Era of digitalisation of healthcare: defining new models of healthcare and patient care services

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ABSTRACT

Demographic projections suggest that the populations of all countries are ageing, with wide-ranging effects on social and health systems. The world's population aged 60 years and older is set to rise from 841 million in 2013 to more than 2 billion by 2050. Digital health is accelerating changes in healthcare much faster than in any generation that preceded us. The digitalisation of health systems has been profound in your transition process, promoting a growing impact on care delivery and providing the opportunity for further reforms focused on prevention. Implementing new digital health solutions in clinical practice is a promising area of development, which is evolving rapidly along with other fields of clinical medicine. In addition, scientific progress in digital health has applications not only in clinical medicine but also in different sectors of activity in healthcare, with equal importance in improving the quality of life. The digitisation of some assistance and clinical practice activities will allow health professionals to have more time to focus on exclusively human tasks, such as exercising empathy and compassion or using judgment and creativity to guide and advise patients. This review aims to address some of the issues surrounding the construction of a new vision of healthcare, including its influence on health equity and its value and usefulness to society (from the patient to the health professional).

Keywords: **Digital health, telemedicine, remote monitoring, e-health, chronic diseases.**

La era de la digitalización de la asistencia sanitaria: definiendo nuevos modelos de servicios sanitarios y de atención al paciente

RESUMEN

Las proyecciones demográficas sugieren que las poblaciones de todos los países están envejeciendo, con efectos de gran alcance en los sistemas sociales y de salud. Se espera que la población mundial de 60 años o más aumente de 841 millones en 2013 a más de 2 mil millones en 2050. La salud digital está acelerando los cambios en la atención médica mucho más rápido que en cualquier generación que nos precedió. La digitalización de los sistemas de salud ha sido profunda en su proceso de transición, promoviendo un impacto creciente en la prestación de atención y brindando la oportunidad de realizar más reformas enfocadas en la prevención. La implementación de nuevas soluciones de salud digital en la práctica clínica es un área prometedora de desarrollo, que está evolucionando rápidamente junto con otros campos de la medicina clínica. Además, el progreso científico en salud digital tiene aplicaciones no solo en la medicina clínica, sino también en diferentes sectores de actividad en el cuidado de la salud, con igual importancia en la mejora de la calidad de vida. La digitalización de algunas actividades de asistencia y práctica clínica permitirá a los profesionales de la salud tener más tiempo para enfocarse en tareas exclusivamente humanas, como ejercer empatía y compasión o usar el juicio y la creatividad para guiar y asesorar a los pacientes. Esta revisión tiene como objetivo abordar algunas de las cuestiones relacionadas con la construcción de una nueva visión de la atención médica, incluida su influencia en la equidad en salud y su valor y utilidad para la sociedad (desde el paciente hasta el profesional de la salud).

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HIGHLIGHTS:

- The incidence and prevalence of chronic non-communicable diseases should be accompanied by increased healthcare services, posing unprecedented challenges to healthcare systems worldwide.
- The digital health area needs a deep engagement of all ecosystem stakeholders, standardised assessment measures, and following international guidelines.
- There are still some resistance points in the medical community, possibly due to the need for more preparation for health digitisation.
- Digital health provides opportunities to accelerate progress in attaining health and well-being related to SDGs, especially SDG 3 – "Ensure healthy lives and promote well-being for all ages.
- Advanced digital tools, including artificial intelligence and the internet of medical things, are setting new standards in personalized and preventive healthcare.

INTRODUCTION

Demographic projections suggest that the populations of all countries are ageing, with wide-ranging effects on social and health systems. The world's population aged 60 years and older is set to rise from 841 million in 2013 to more than 2 billion by 2050[1,2]. The incidence and prevalence of chronic non-communicable diseases, including cardiovascular disease, stroke and dementia, are also becoming more expressive among older groups in the population[3,4]. This scenario should be accompanied by increased use of healthcare services, posing unprecedented challenges to healthcare systems around the world[1,2]. These challenges call for a paradigm shift in care provision and healthcare models.

The term digital is based on the concept of eHealth, which is defined as "the use of information and communications technology in support of health and health-related fields"[5]. Digital health is accelerating changes in healthcare at a much faster rate than in any generation that preceded us. The digitalisation of health systems has been profound in your transition process, promoting a growing impact on care delivery and providing the opportunity for further reforms focused on prevention[6,7]. New digital solutions have the potential to enhance access to health information, thereby facilitating preventive and personalised medical approaches for both patients and healthcare professionals. These innovations support not only patient self-management in health but also enable healthcare providers to tailor their practices more effectively to meet individual patient needs[8]. Also, its potential to reduce health inequalities allows people to access digital health information and tools to help them to better manage their health and care[9]. Such solutions also help bridge gaps in care provision accounting for projected shortages of healthcare workers[8].

Moreover, health interventions resorting to new technologies have enormous potential to evaluate the impact based on effectiveness, efficiency and safety[6,10], contributing as support to the decision[11,12]. For instance, a new wave of portable biosensors and other wearable devices is already revolutionising biomedicine through mobile and digital health by enabling continuous, longitudinal health monitoring outside of the clinic settings and predicting health events[13,14]. These devices can be activity meters, scales, sphygmomanometers, glucometers, smart pillboxes, and connected via Bluetooth or wireless[15], the smartwatches and fitness trackers the most popular[16]. As we will address later, the new digital health solutions may also include more complex systems than these everyday devices[8]. It can be considered the tip of the iceberg when we consider all the possibilities they offer to transform the healthcare services[17]. The products and services included in the concept of "digital health" aim at benefiting patients and/or healthcare systems through the pursuit of the following objectives: to improve the quality of outcomes of healthcare services; to improve population health; to improve the patient experience and satisfaction; to improve the physician and other healthcare providers' experience; and to address disparities in access to healthcare[18].

This article aims to explore and address the multifaceted challenges of developing a new healthcare paradigm, with a particular focus on its impact on health equity and its overall significance and utility to society. The exploration is conducted through the dual perspectives of patients and healthcare professionals, emphasising the comprehensive impact on these crucial stakeholders.

Digital health fields & current applications in healthcare

Several emerging technologies, spanning a broad spectrum beyond mere computer and data sciences, drive a highly diversified digital health revolution. This expansive transformation significantly influences clinical decision-making, regulatory practices, and health policy formulation, showcasing the widespread and varied impact of digital advancements across the healthcare sector[19]. The use of digital information, digital data, or communication technologies allows for the collection, sharing, and analysis of information. The data will contribute to improving the provision of healthcare, including several dimensions[20,21]:

- e-Health: area resulting from the intersection between medical informatics, public health and business, referring to health services or information made available or enhanced by the Internet and related technologies[22,23];
- Mobile Health (m-Health): use of mobile and wireless technologies to support health goals[20];
- Intelligence health: use of emerging technologies in computer sciences (e.g., artificial intelligence [AI]), data sciences (e.g., big data and predictive analysis) and genomics, applied to the health area[20,21];
- Wearable Technology: wearable devices that monitor health data in real-time, such as smartwatches that track heart rate, physical activity levels and sleep pattern[13];
- Virtual Reality (VR) and Augmented Reality (AR) in healthcare: Use of VR and AR for medical training, rehabilitation and treatment of mental health conditions such as phobias and post-traumatic stress disorder[13].

On the other hand, although there are some digital products and services that are associated with different technologies, Horgan et al. (2019) classified them into the following subcategories: remote sensing and wearables; telemedicine and health information; data analytics and intelligence; predictive modelling; health and wellness behaviour modification tools; bioinformatics tools (-omics); medical social media; digitized health record platforms;

patient-physician-patient portals; self-diagnostics, compliance, and treatments; decision support systems; and imaging[18]. Digital systems are based on software or can be incorporated into hardware, with numerous applications in medicine. Incorporating systems and algorithms differentiates the final product: we may be talking about medical devices (and therefore subject to evaluation by the regulator in this sector) or generic digital devices without the need for qualified approval by health regulators[24].

Globally, the clinical community rapidly recognized the potential of digital health to tackle many challenges experienced by health systems, including early diagnosis, access to care, and equitable provision of services[25]. Even so, there are still some resistance points among the medical community, possibly due to the lack of preparation in health digitization[26]. Concerning this phenomenon, four widely discussed reasons should be provided: (i) the poor preparation of physicians regarding the discipline of digital health, leading to barriers in its implementation in clinical practice; (ii) early digitization of health processes accompanied by a heavy administrative burden, particularly in clinical records[27]; (iii) fear of AI replacing physicians[28], although there are reports in the literature that it will mainly help the work of these health professionals[29,30]; and (iv) the current lack of a sufficiently robust legal framework, which defines the concept of medical responsibility in case of accepting or rejecting the recommendations of the algorithm instilled in the digital system[31]. In addition, addressing these challenges necessitates a concerted focus on continuous education and training in digital health for healthcare professionals. This would include not only technical skills but also an understanding of ethical, legal, and social implications[32]. Furthermore, fostering interdisciplinary collaboration and ensuring seamless integration of digital health systems within existing healthcare infrastructure are crucial for maximizing the benefits of digital health innovations. In this sense, overcoming the concerns of health professionals, particularly the medical profession, maybe the key to obtaining successful digital solutions in clinical practice, promoting a visible improvement in clinical outcomes, with consequent gains in patients' quality of life of patients[33].

There are already many digital solutions available on the market with robust evidence of their benefits for patients' quality of life. This array of solutions may cover both the prevention and diagnosis of diseases, offer support for activities of daily living or monitor health status and well-being. The table below describes some applications of digital solutions in the health field (Table 1).

Table 1. Examples of current digital health solutions applied in clinical and regulatory healthcare fields

Intervention area	Practical use
Cardiovascular risk	Digital solutions using AI have been widely used to predict cardiovascular risk (e.g. acute coronary syndrome[34], heart failure[35] and stroke[36]).
Geriatric oncology	Remote digital health technologies have shown to be a great support in multiple aspects of geriatric oncology[37], namely in the monitoring of symptoms in the disease and treatments (e.g. pain[38] and skin manifestations[39]) and telephone communication[40].
Neurology	E-Health, previously presented, increasingly used in the field of neurology, namely in multiple sclerosis, in terms of information conveying and sharing, rehabilitation, and disease management[41].
Mental health	Technological innovations and solutions are being considered in an attempt to address the size and scale of the mental health crisis worldwide[42,43]. New sensors and data, such as those derived from increasingly ubiquitous smartphones, offer a new window to the functional, social and emotional experiences of mental diseases[44]. Digital applications for bipolar disorder also seem to be beneficial by promoting the permanent monitoring of these patients[45].
Endocrinology	Among the multiple tools available in this field for the most varied diseases, we highlight the real-time monitoring of interstitial blood glucose levels in diabetic patients[16,46-48].
Rheumatology	In chronic care, such as rheumatology, digital solutions with powerful sensors allow you to monitor patient symptoms in real time and provide useful information on disease progression[49,50].
Allergology	Asthma, as a chronic condition, has seen many emerging technologies emerge to support the patient[23,51,52]. These technologies have the advantage of tracking asthma symptoms and medications, setting drug reminders, improving inhaler technique and delivering asthma education.
Diabetes Management	Digital health tools such as continuous glucose monitors (CGMs) and insulin pumps integrated with smartphone apps help patients manage their blood sugar levels more effectively, providing real-time feedback and data sharing with healthcare providers[53].
Respiratory Care	Mobile applications and connected devices for conditions like asthma and COPD (chronic obstructive pulmonary disease) allow for better monitoring of symptoms, medication adherence, and remote consultations with specialists[54].
Oncology	AI-driven platforms are used to personalize cancer treatment plans by analyzing large datasets from various patients, helping to predict responses to different therapies and optimizing treatment protocols[55].
Regulatory Sciences	Digital health solutions are being applied to streamline regulatory processes, such as automating compliance checks[56], enhancing data submission and review processes[57], and improving post-market surveillance.
Pharmacovigilance	Digital health solutions are being utilized to enhance pharmacovigilance activities, such as monitoring adverse drug reactions[58], detecting drug interactions[59], and ensuring medication safety[60].

Regardless of the area of intervention and the digital solution used, it is necessary to ensure effectiveness in its use. There is still a lot of AI software without proper clinical validation, which raises significant concerns[61].

The technologies that digital health draws upon include telemedicine, mobile phones and applications, wearable devices, robotics, virtual reality, AI and genomics[8]. These digital solutions can be evaluated in the hardware or software component, increasingly using big data that comprise significant quantities of health information and sophisticated analysis with AI[57]. Although these resources are available, the question prevails: should we use wearables to screen for health conditions? As we mentioned in the previous topic, the intervention using digital solutions will depend on the known efficacy and, above all, the clinical decision[62].

Evaluation of digital solutions in chronic disease

One of the challenges of managing older individuals with chronic diseases is individualising care in people with multimorbidity's[63]. Technology has revolutionised care models, connecting healthcare workers to the people they serve. Digitalisation is gradually being incorporated into the care of patients with chronic diseases and can facilitate the implementation of new and innovative care models as part of health systems reforms[64], benefiting patients with short and long-term health improvements[65]. In this context, new research lines should be considered[66] to provide answers to patients, caregivers, and health workers. As previously mentioned, all stakeholders of digital health transformation must be able to make decisions based on the previous results of these solutions. For this, new solutions must be carefully appraised regarding their effectiveness, using objective health measures over time instead of focusing only on descriptive data[67].

Despite everything mentioned above, digital solutions only present added value to the health system if evaluated methodologically. The World Health Organization (WHO) developed a framework to evaluate digital health interventions divided into two major processes: monitoring and evaluation[10]. The first includes functionality, fidelity, stability and quality, while the second consists of usability, feasibility, efficacy, effectiveness, economic/financial evaluation and implementation research[10]. Also, in the business world, there is increasing interest in principles that specific methods for early-stage testing, such as acceptability, usability, demand, implementation, practicability, adaptation and integration[68]. For instance, in a systematic review of the economic evaluations of digital health, unknown cost-effectiveness was listed as a major barrier to implementing these new solutions[69]. These conclusions show the need for further studies, as cost-effectiveness evaluation studies, to support the decision to include a specific digital intervention in the health system[43,70].

Towards an equitable digital public health era

The integration of digital health solutions is pivotal in addressing health disparities and achieving equity in public health. Personalized digital health technologies play a crucial role in tailoring healthcare to meet the unique needs of diverse patient populations. Bathija et al. (2023) emphasize the importance of personalizing the patient experience to achieve digital health equity. Their study highlights how tailored digital health interventions can improve access to care, patient engagement, and health outcomes, particularly among underserved populations[71].

In the realm of cardiovascular care, digital health innovations offer significant opportunities to enhance equity and diversity. Hernandez and Rodriguez (2023) discuss the concept of Health Techequity, which leverages digital tools to bridge gaps in cardiovascular care. They provide examples of how telehealth, remote monitoring, and AI-driven predictive analytics can improve the early detection and management of cardiovascular diseases in diverse communities. This approach not only promotes equitable access to care but also ensures that interventions are culturally and contextually relevant, ultimately reducing disparities in cardiovascular health[72].

Moreover, advancements in digital health are enhancing regulatory sciences by streamlining compliance checks, data submission, and post-market surveillance processes. These innovations are crucial for ensuring that all populations benefit equally from new healthcare products and interventions. By integrating AI and machine learning, regulatory bodies can more effectively monitor and respond to safety issues, ensuring that digital health solutions are safe and effective for all users[73].

Together, these efforts underscore the transformative potential of digital health in creating a more equitable public health landscape. By focusing on personalization, diversity, and inclusivity, digital health solutions can help bridge the gap in healthcare access and quality, fostering a healthier and more equitable society.

Digital health to strengthen health services: value and utility

Evaluating the digital health solutions and interventions over time attempts to attribute a range of outcomes to the technology-based intervention – this is the effectiveness[10]. There are several cases where the positive effects of using health technologies were demonstrated. For instance, a systematic review of 2018 concluded that most of the interventions analyzed showed an increase in patient compliance in the management of chronic disease and, consequently, an increase in the clinical results of the respective diseases[74]. Telemedicine is also playing a critical role nowadays due to the possibility of remote access to some health services. One of the legitimate questions in this field is: should telemedicine be more effective than other standard interventions? If we look at the particular case of diabetes, it seems that telemedicine - essentially text messaging and web portal - contributed to the improvement of HbA1c, although there were no changes in other results, such as quality of life or mortality[75]. In the field of diagnosis and screening, digital health solutions have become increasingly important. The new digital health innovations have opened up several opportunities to help the clinicians, patients and other caregivers that deal with cancer diseases[76], rheumatic diseases[49] or even multiple sclerosis[41], assisting screening and diagnostics and contributing to cost reduction workflow inefficiencies and improvement of clinical outcomes[77]. Still, hypertension has special attention in healthcare services in chronic diseases since it is one of the main cardiovascular risk factors, with a prevalence of 1 in each man and 1 in 5 women, in 2015[78]. Previous systematic reviews have concluded that

strategies in digital health seem to add value to the standard of care practices; however, intervention studies with larger samples are necessary to understand which modalities are most effective in some specific populations[7-9]. These technologies will continue to transform and add value to patient care worldwide. However, based on the examples above, the value and usefulness of health solutions must always be evaluated considering the disease, the target audience, the modifiable outcomes and the health intervention.

Final considerations and future directions

As we conclude this discussion on digital health, it is clear that integrating these technologies is not only beneficial but essential for the modern healthcare landscape. Successful integration requires the active participation of all stakeholders, guided by standardised assessment measures and international guidelines, such as those outlined in the WHO's "Monitoring and Evaluating Digital Health Interventions: A Practical Guide to Conducting Research and Assessment" (2016)[10].

Robust evidence enables healthcare workers to make informed, safe clinical decisions and positively influence public health policy. As digital health solutions evolve alongside clinical medicine, they offer significant opportunities to enhance patient care by allowing health professionals to devote more time to human-centred tasks. This improves the quality of care and leverages digital advancements for personalised medicine across various healthcare sectors.

The digitisation of healthcare requires ongoing education and interdisciplinary collaboration to ensure smooth and effective integration within existing health systems. Developing robust legal and ethical frameworks to support these integrations is critical to addressing the concerns of health professionals and maximising the potential of digital health innovations. By focusing on these areas, we can pave the way for more personalised, efficient, and equitable healthcare systems globally.

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