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EDITORIAL

# *Editorial—The New Frontiers of Digital Medicine*

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In the last decade, tremendous progresses in heath technologies prompted the vigorous rise of digital heath (DH) as one of the most promising branches of medicine. The Food and Drug Administration (FDA) defined DH as "a convergence of people, information, technology, and connectivity to improve health care and health outcomes" [1]. Several different technologies (including both instruments and bioinformatics) fall under the DH umbrella and have the potential to completely transform clinical approaches to bedside care and overall health care [1].

Among others, there has been a significant advancement in the technology of smart wearable devices, allowing them to expand their capacity to collect patient-related data, and digital biomarkers, including physiological and behavioral data, in the so-called *Internet of things* [1]. Of note, digital biomarkers range from those that indicate the possibility of disease development in a healthy individual (susceptibility), or confirm the presence of a disease or suspected condition (diagnosis), to those that measure the status of a disease or medical condition (monitoring), those that identify the possibility of a clinical event (prognostic), and those that assess the biological response of an individual receiving drug therapy (pharmacodynamic). As a result, multiple controlled clinical trials have been conducted, which have proved their validity and safety.

These digital diagnostics have resulted in the growth of digital therapeutics and specialized software (such as apps) capable of successfully and measurably guiding patients' progress toward improving their clinical condition [1]. These technologies

are clinically validated treatments for a wide range of disorders, with a special focus on pathological conditions involving behavior and psychological components. In this review paper, we discuss some of the most recent advances in this field [1].

In the latest issue of *Digital Medicine and Healthcare Technology*, some new and interesting applications have been presented with potential clinical relevance.

First, Dr. Biran and Dr. Jeremic proposed the use of electrocardiography (ECG) signals as biometric trait for human identification [2]. In general, a biometric trait needs to satisfy a series of requirements to be used for individuals recognition, including (1) universality (the trait should be present in living population), (2) Uniqueness (major differences in trait characteristics should be derived among different people), (3) collectability (the trait should be quantitatively measurable and easily accessible), (4) acceptability (the trait should be user friendly and widely acceptable), (5) resistance to circumvention (the trait should be resistant to the various spoofing attacks), and (6) permanence (the extent to which the trait features should remain stable over time). In this regard, ECG based biometric systems achieved satisfactory identification accuracy in a wide range of applications [2]. In fact, The ECG has several major advantages, the most important of which are its hidden nature and the assurance of liveness, which make it preferable to other biometric modalities such as face, fingerprint, and iris, which can be damaged or stolen [2]. On the other hand, ECG stability can be questioned as cardiac signals are highly affected by many geometrical, individual, and technical factors. In their study, the authors analyzed signals taken on different days and applied a filtering system that is based on *The Maximal Overlap Discrete Wavelet Transform* (MODWT), that allowed a remarkable efficiency, with up to 98.07% identification accuracy, and fifty three subjects having a personal identification accuracy ranging from 90 % to 100% [2]. They concluded that ECG might improve patients' security in clinics, especially if combined with a "conventional" system (e.g., iris) [2].

Another interesting application was presented by Dr. Room and Colleagues [3]. They focused their study on the use of telehealth (suddenly become a need during the recent Covid-19 pandemics) for group-based pain management [3].

The telehealth groups met once a week for 3 hours via zoom and ran over a course of 6 weeks in which chronic pain (CP) self-management techniques were taught. Pain outcome measures were taken at baseline and after the final telehealth meeting. Furthermore, the measures around pain neuroscience understanding were evaluated at baseline and post-intervention. Finally, therapeutic alliance (TA) and group dynamics (GDs) were assessed at post-treatment using a questionnaire [3]. Of note, TA and GDs showed a significant predictive relationship with improved changes in maladaptive pain behaviors and pain self-efficacy. Further, the authors also found a statistically significant predictiverelationship between maladaptive pain behavioral

changes and improvements in pain self-efficacy, pain catastrophizing and pain kinesiophobia [3]. Based on that, they concluded that building an enhanced TA and working with the group of patients to form tightened GDs should be encouraged to improve the quality of life in patients with CP [3].

The use and implementation of artificial intelligence (AI) is one of the main features of digital medicine. AI is the ability of intelligent machines to predict unknown variables by using algorithms, internal statistical patterns and information structures. In the structure of AI, which are divided into two general categories, machine learning and deep learning, human neural patterns are in the form of neural networks [4]. Dr. Yeganeh revised all literature about the use of AI in oromaxillofacial surgery, and found relevant claims in the fields of rhinoplasty and orthogognatic surgery. As far as the first was concerned, the author could recommend AI, based on evidence, for examining bone shape, examining the beauty of patients based on the evaluation of pre-treatment photographs and predicting the results of the operation based on radiographic interpretation. Regarding the second one, evidence from literature indicted that AI can be used in the field of lateral cephalometric tracing, scanning of patients' occlusion, examination of periodontal diseases and dental problems, as well as making oral appliances and predicting the operation using machine learning.

Of note, the application of digital technologies to dentistry was further revised by Dr. Haidar, including all fields of dentistry, including diagnosis, treatment planning, and restoration and a wide range of technologies [5]. Computer-aided design/computer-aided manufacturing (CAD/CAM), three-dimensional (3D) printing, artificial intelligence (AI), augmented reality (AR), and teledentistry are examples of rapidly growing and transformational technology. AI algorithms can be used to analyze dental X-rays and other images to help dentists make more accurate diagnoses. For example, a deep learning algorithm trained on a large dataset of X-rays can quickly identify patterns associated with common dental conditions such as cavities, gum disease, or oral cancer [5]. Not less relevant, nanotechnologies can be adopted (so called *nanoDentistry*) to create new materials and devices with unique properties [5]. Other remarkable practical applications certainly include digital occlusal analysis, that involves the use of digital sensors to analyze a patient's bite and occlusion. This technology can identify areas of high pressure or wear on the teeth, which can help dental professionals diagnose and treat conditions such as temporomandibular joint disorder. Further, AI and ML algorithms can be used to design dental prosthetics such as implants, bridges, and dentures. In addition, digital smile design (DSD), uses digital imaging software to build a virtual 3D model of a patient's teeth and gums. This model can then be utilized to create a personalized treatment plan to enhance the appearance of the smile [5]. Finally, *teledentistry* is a type of telemedicine that uses digital technologies to deliver dental

care and consultation remotely, allowing patients to receive dental consultations, tests, and even some treatments without having to travel [5].

Overall, the author showed evidence that the use of digital technologies in dentistry has transformed the field of dentistry, improving the precision, accuracy, and efficiency of dental procedures, as well as patient outcomes [5]. Nonetheless, relevant issues also raised up such as ethical (patients' privacy, for instance) and economical (since the adoption of new technologies requires special training and investments for all professionals) that need to be carefully evaluated before adopting new digital technologies.

Other caveat did emerge from the studies by Dr. Smith and Colleague [6] and by Dr. Tisman and Dr. Seetharam [7]. First, the limitations and barriers affecting the use of remote monitoring in some common chronic diseases, such as diabetes and hypertension, were investigated by using an adapted version of the Barriers to Health Promoting Activities for Disabled Persons Scale (BHADP) [6]. Of note, it was observed that patients and caregivers/care providers perceive possible barriers differently. Providers believe that technology should be easily integrated into the patient's daily routine, whereas patients believe that technology disrupts their routine [6]. Based on the three most significant hurdles identified by physicians, one may conclude that a little bit of training and information about the technology would erase the barriers for the patient [6]. By contrast, patient did not indicate educational needs as a significant barrier. Rather, the most common patient hurdles were a lack of time in their day and mental health issues [6]. In this regard, noteworthy, people with chronic disease have higher prevalence of mental health disorders, and the present study implies that mental health issues may have a greater impact on chronic disease care than physicians realize [6].

Finally, a study highlighted differences among different AI algorithms in cancer patients management, raising a warning on their use without adequate training and controls. Particularly, the authors challenged three different platforms with a case of tonsillar carcinoma. They documented frequent changes of responses to unchanging prompts over just hours and days within the same and between the three examined large language models (LLMs), with critical errors of guideline-recommended drug therapy [7]. In this regard, several AI-supplied references were false AI-generated references, whose DOI and or PMID identifiers were either nonexistent or led to completely irrelevant manuscripts on other subjects [7].

In conclusion, new technologies and specially AI are promising remarkable steps in the advancement of medicine; however, caveat still exist, and digital medicine still largely requires validation in many fields.

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