REVIEW ARTICLE

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Health 4.0 in the medical sector: a narrative review

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INTRODUCTION

The introduction of technological resources in health and medicine has led to numerous innovations[1,2]. However, there is still a lack of feedback and decisive actions to deliver services and products that reduce costs and improve evaluation, diagnosis, and medical treatment[3,4]. "Health 4.0" is a concept that encompasses the use of technologies such as Big Data, Internet of Things (IoT), cloud computing, and artificial intelligence (AI) to improve health care. These technologies can potentially improve the quality of care, reduce costs, and make health care more accessible[5].

However, challenges must still be overcome before "Health 4.0" can be fully realized[5-8]. These challenges include the promotion of health literacy, adherence to the use of technologies, and organizing infrastructure for optimal and real-time conduction of the indicators[9-11]. This study aimed to discuss the challenges and possibilities of "Health 4.0" in the medical sector regarding information and knowledge management, efficiency and effectiveness of the service, and the current level of evidence.

METHODS

The SANRA guideline[12] was used to organize this narrative review. Articles indexed in the following databases were used: Latin American and Caribbean Literature in Health Sciences (LILACS), Scientific Electronic Library Online (SciELO), PubMed, and Web of Knowledge, with the following filters: (1) research published in the past 10 years (October 2012 to October 2022) and (2) systematic reviews and/or meta-analyses. The following indexing terms or descriptors in Portuguese and English were used: "health 4.0" and "big data" or "internet of things" or "cloud computing" or "artificial intelligence." A total of 23 articles on the proposed theme were included in the final analyses.

RESULTS AND DISCUSSION

The results of this study are divided into three sessions, including "Health 4.0": (1) information and knowledge management; (2) efficiency and effectiveness of care; and (3) current level of evidence.

Information and knowledge management in "Health 4.0"

The use of devices in 4.0 health has generated data that need to be analyzed to turn it into information that guides evidence-based practice[13]. Medical companies and professionals must establish strategies to manage these data and create mechanisms to explore the information collected[14]. One strategy is to use software that provides health professionals with specific guidelines or recommendations to assist in their diagnosis, disease management, and treatment.

This software, called Medical Decision Support Systems, can reduce diagnostic time and improve the quality of care for patients[15]. Wearable devices that feature Internet-based technologies, which have been related to monitoring the level of stress, amount, and quality of sleep, asthma, chronic obstructive pulmonary disease, cardiovascular diseases, diabetes and nutrition, aspects related to gait and falls, neurological diseases, recognition of physical activity, and rehabilitation, among other functions[16].

The data processing systems that reproduce human cognitive functions' speed and ability to relate and analyze information exponentially have been discussed in the literature before the economic impacts on health care[17]. Cozzoli et al.[14] discussed

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that big data analyses are considered a milestone for managing studies applied to health organizations, although scientific research lacks investigations regarding the standardization and integration of devices.

The increase in the potential for big data is associated with continuing medical education, based on (1) transformation of data related to learning with medical systems; (2) intelligence in health based on learning about innovation in health and forecasting processes; (3) data collection to understand the patient's profile; and (4) learning based on clinical decision-making in health[18]. The collected data can boost learning and revolutionize the medical industry since they store up-to-date knowledge from innovative research[18]. Medical companies that acquire medical technologies, hardware, and software must also invest in continuing education and research to make informed decisions about diagnoses, treatments, medication selection, and follow-up[19].

The conduction of randomized clinical trials is fundamental for advancing processes related to Health 4.0, such as the development of artificial technologies, big data, cloud, cybersecurity, telemedicine, and wearable devices, to improve global digital health strategies[20]. It is concluded that processes linked to Health 4.0 need to be tested on a large scale in health centers to improve the systems and the services that will be provided.

Efficiency and effectiveness of care

The literature has discussed the economic evaluation, impact of technologies, and process management of Health 4.0. Voets et al.[21] noted that the economic evaluation of AI is limited to financial costs, and there is a lack of short-, medium-, and long-term evaluations of possible impacts on health. Pinto de Paula Filho and Lamy[22] pointed out that there will be no real progress in the development of Health 4.0 if medical companies do not understand the impacts of these technologies on companies and patient care.

The current level of evidence of "Health 4.0"

The DXplain software is used to compile medical information to make possible diagnoses from laboratory data, history, and symptoms, generating a list in descending order of importance also indicating further investigations, and the HELP system, which is an integrated performance system with a computerized medical record system, which contains patient information[23]. As the doctor enters patient data, the system can make reminders and alerts, interpret data, and diagnose diseases[23].

DXplain has a knowledge base that includes more than 2,400 diseases and more than 5,000 clinical findings in medicine[15]. The PathOS software was developed to support rapid clinical diagnosis needs; this software has proven robust after 2 years of use at the Peter MacCallum Cancer Center for analysis, genetic test reporting, and curation for cancer patients[24]. Esteva et al.[25], using a set of 14,000 images already diagnosed by dermatologists, asked the system to recognize three types of lesions: benign, malignant, and noncancerous growths. The percentage of correct answers for the AI system was 72%, and for dermatologists, it was 66%[25].

The technology can be applied in other specialties if the image is adapted[24]. Bhalodiya, Keung, and Arvanitis[26] observed promising results of AI in identifying tumors via magnetic resonance. Nonetheless, the authors suggest that the algorithms must be improved. Similar responses were identified by Li et al.[27], who argued that AI algorithms require improvements to diagnose non-alcoholic fatty liver disease more assertively. Other studies have investigated highly relevant aspects of the health and quality of life of asthmatics, such as Li et al.[28] who used a sensor to measure airborne formaldehyde levels. However, the study systematized the prototype, but so far, the next step has not yet been carried out, which will be useful to test the equipment's efficiency in monitoring formaldehyde.

In turn, Tran, Ngo, and Tong et al.[29] developed an application for detecting falls based on machine learning, in which the respective authors consider that the technology can differentiate a fall from some other joint event, such as sitting and jumping. Thus, it is considered that the two technologies presented in the studies[28,29] have great potential but need to be tested in controlled clinical trials. During the COVID-19 pandemic, health technologies enabled the elaboration of remote diagnosis through devices, and the non-drug treatment of obesity and associated comorbidities[9], drug treatment, and medical equipment were delivered to isolated areas[30].

Another contribution was monitoring patients infected by the virus through devices and interconnected networks[30]. Al-Arkee et al.[31] pointed out that applications to increase adherence to drug treatment of cardiovascular diseases seem to be effective, but it was discussed which components would be effectively essential for patients. The same authors mentioned that developing large-scale studies would be relevant for improving applications[31]. The study carried out by Nasajpour et al.[30] to determine the role of technologies such as wearables, smartphone applications, and others that are based on IoT in the tracking and control of COVID-19 and how they act in the three main phases – early diagnosis, quarantine time, and after recovery

– showed that, in all phases, the technology based on the IoT showed good and promising results[30,32].

The same authors consider that fine adjustments should be made as more information about the virus's behavior is collected, as this is the only way to reduce the impacts of this type of disease significantly. Considering the heterogeneity of diagnoses[33] before the dissemination of information, diagnosis, and direction of clinical conduct based on the responses of mobile technologies, more clinical, controlled, and randomized studies demand to be carried out to increase the assertiveness of diagnoses based on new technologies.

Recently, Akhtar et al.[34] argued that new technologies have significantly influenced health services, with the beginning of the electronic medical record, a new era of digital health, and the emerging growth of techniques that aim to implement robotic surgeries and algorithms for machine learning, which can even replace the health professionals in the future. Additionally, Battineni, Hossain, and Chintalapudi[35] also pointed out that the information collected in "biobanks" may predict possible pathological outcomes based on AI, which will probably lead to precision medicine research and guide the population's health services.

FINAL CONSIDERATIONS

Health 4.0 has emerged as a promising field that could revolutionize health care. However, more research is needed to validate the effectiveness of these technologies and develop treatment protocols. Medical companies need to deeply understand the technologies already present in Health 4.0 to optimize their services. Integrating new technologies with professionals in this segment can develop predictive, preventive, personalized, and participatory work.

The information presented in this article is expected to guide future research concerning Health 4.0. In particular, randomized clinical trials with the testing of protocols, use of comparison groups, exponent technologies versus conventional treatment, and gold-standard measurement versus new measurement protocols, among other possibilities, are indispensable.

AUTHORS' CONTRIBUTIONS

ACJ: Conceptualization, Data curation, Investigation, Writing – original draft. **EMD:** Conceptualization, Data curation, Investigation, Writing – original draft. **MLDS:** Conceptualization, Data curation, Investigation, Writing – original draft. **BHMB:** Conceptualization, Data curation, Investigation, Writing – original draft.

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