Digital Technologies Adoption to Face COVID-19 Pandemic: An Exploratory Approach

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Abstract. The biggest public health emergency of the 21st century, COVID-19, a disease caused by the new SARS-CoV-2 coronavirus, has challenged health systems on a global scale. In this pandemic scenario, digital technologies show themselves as alternatives to fight the disease. Therefore, this article aimed to map the application of digital technologies in the scope of the COVID-19 pandemic. To this end, an exploratory study was developed, with a qualitative approach and through the application of bibliographical research based on a systematic review. The mapping and discussion of the application of strategies from the Fourth Industrial Revolution in actions to combat SARS-CoV-2 pointed to Augmented Reality, Additive Manufacturing, Collaborative Robots, Big Data Analytics, and Internet of Things as enablers to prevent, detect, and manage COVID-19 disease, promoting telehealth, intelligent tracking of infected individuals, real-time medical data sharing, rapid prototyping of critical devices, among others. Reports in the literature suggest the importance of a robust technological apparatus to face this sanitary challenge, which should be one of the focuses for the development of new public policies.

Keywords: COVID-19 · Health 4.0 · Industry 4.0 · Digital technologies

1 Introduction

The accelerated pace of technological development is changing the way society operates, reaching a wide spectrum of segments of the economy. Currently, in the Fourth Industrial Revolution associated with Industry 4.0, an attempt is made to leverage individualization and digitization in different industrial domains, based on pillars, attributes, and technologies arising from this new paradigm [1].

The exploration of the technological apparatus of an organization, or even a country, acquires peculiar importance in emergency episodes and intense demand for new

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solutions. In this perspective, humanity is currently experiencing the greatest sanitary challenge of the 21st century, which has become a public health emergency worldwide, placing the COVID-19 disease, caused by the new Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), as one of the issues most debated in the literature [2–4]. Among the strategies to fight this disease, intensive measures in science and technology have assumed a crucial role, so that some technological weaknesses become a bottleneck, especially in emerging countries [5].

In the pandemic scenario, which has significantly affected healthcare facilities on a global scale, technologies 4.0 stand out by providing advanced digital solutions for the diagnosis, management, and combat of the disease, favoring the speed of response and power of early detection of systems [1, 3]. From the dissemination of the new coronavirus, emerging technologies moved from a gradual adoption, in the medical scope, to a faster and more effective insertion, making both Industry 4.0 and the pandemic to be considered revolutionary phenomena that lead to disruptive changes [6].

Therefore, this article aimed to map the application of digital technologies to fight the COVID-19 pandemic. This study is not only justified by evaluating the actions and procedures portrayed but its contribution is also suggested to optimize indicators of combating the disease, especially about the development of public policies.

2 Theoretical Framework

Proclaimed as a pandemic on March 11, 2020, by the World Health Organization (WHO), COVID-19, since its appearance in Wuhan, China, has affected more than 200 countries and regions, surpassing the number of 126 million cases with nearly 3 million deaths by March 2021 [7]. Referring to the spread of a new disease on a global scale whose transmission is sustained from individual to individual, the term “pandemic” is not only considered as a challenge in public health but refers to an alarming situation that generates profound socioeconomic and policies to affected countries [8].

Characterized as a single-stranded RNA virus with a diameter ranging from 80 to 120 nm, SARS-CoV-2 is highly infectious and can be transmitted from close contact with an infected person, on exposure to coughing, sneezing, or droplets. As one of the leading causes of hospitalization and death today, the new coronavirus has become a major concern for governments around the world trying to join efforts to fight the pandemic globally through different measures and protocols [8, 9].

From this perspective, the digital technologies arising from the Fourth Industrial Revolution stand out as a strategy to fight COVID-19 disease, as well as enabling the resumption of routine activities even in a virtual environment. The concept of Health 4.0 emerges in the medical industry referring to the various applications of digital technologies from process management to research and development of new devices [1].

There are reports in the literature that point to the feasibility of virtual medical consultations, based on telemedicine and Artificial Intelligence (AI), as well as the medical teaching and learning process in remote areas, which are practices that are currently applied [3].

Through an integrated environment based on real-time data sharing, health stakeholders interrelate to develop and test vaccines, drugs, and new devices, in addition to

acting in the verification, surveillance, detection, and decision of the actions necessary to treat COVID-19 disease with less human physical involvement. As a result, there is a reduction in the agglomeration of people, both in public areas and in hospitals, which inhibits the spread of the virus [3].

According to [10], the importance of Big Data Analytics (BDA) can also be mentioned, since, in health, there is a wide variety of data to be extracted and analyzed regarding diseases, prevention, treatments, diagnoses, injuries, and disabilities to improve health care outcomes. Augmented reality (AR) has been applied in several surgeries in the hospital area, helping physicians in the decision-making process [11]. Also, standout autonomous robots, such as chatbots, which are algorithms programmed to interact with humans naturally, have helped patients in medical treatment [12].

Therefore, it is observed the implementation of digital technologies in the healthcare field is already a reality and a promising strategy to generate substantial growth in medical sciences with important innovations [1, 13].

3 Methodology

This article presents an exploratory and descriptive study based on the collection and analysis of secondary data, using bibliographic research as a strategy to enable the standardization of information about the application of digital technologies in the scope of the COVID-19 pandemic.

A systematic literature review was developed, using PubMed, Science Direct, and Web of Science as databases. As restriction parameters, the time horizon (2019–2021), language (English), and type of document (only articles from journals and scientific conference proceedings) were applied. All identified and selected papers were transferred to the Mendeley software to provide reference management, as well as to avoid possible duplication of sources that were published in more than one database.

The choice of keywords and research arguments was carried out according to the scope of this work, aiming to identify current and relevant articles that address digital technologies and COVID-19, encompassing diagnosis, management, and combat of the disease. Therefore, the main fields of research included the terms Industry 4.0, Health 4.0, technology, digital technology, pandemic, and COVID-19.

The search fields for the identification of articles were limited to the abstract, title, and keywords, these items being decisive in the selection of the source. The systematic review flow included criteria for inclusion and exclusion of articles, the definition of data to be selected from the articles, and the analysis, discussion, and presentation of results [14].

4 Results and Discussion

According to the systematic review developed, the main digital technologies that are being applied to fight COVID-19 refer to AR, Additive Manufacturing (AM), Automated Guided Vehicles (AGV), BDA, and the Internet of Things (IoT), according to Table 1.

Table 1. The main contributions of digital technologies to face the COVID-19 pandemic.

Technology	Adoption to face the COVID-19 pandemic	References
AR	Education and skills training of health professionals without the need for physical contact	[11, 15]
	Psychological treatment of patients with COVID-19 in social isolation	[16]
	Remote support, training, and communication between employees in the manufacturing environment	[2]
	Monitoring of health status and issuing safety alerts to employees in the manufacturing environment	[2]
AM	Fast and flexible prototyping to support critical medical device shortages	[17, 18]
	Use of raw material in the production of medical devices that reduce the viability of the virus and help in activating the COVID-19	[17, 18]
AGV	Monitoring and clinical care for patients with COVID-19 in the hospital environment	[4, 12, 19]
	Disinfection in medical areas	[4, 12, 19]
	Automation of operational tasks for health professionals and minimization of physical contact between doctor and patient	[4, 12, 19]
	Logistics and transport of medical devices as well as online product deliveries	[4, 12, 19, 20]
	Socioeconomic functions - social interaction support for people in a quarantine situation	[19]
	Automation of industrial processes and promotion of social distance in the manufacturing environment	[2, 21]
BDA	Real-time population data collection for global database formation	[3, 5, 10, 22, 23]
	Development of epidemic maps for understanding and simulating the spread of the virus	[3, 10]
	Quality and data security control, respecting privacy and confidentiality	[23]
	Automated treatment centered on the individual	[5, 13]
	COVID-19 intelligent diagnosis and treatment assistant program (ncapp)	[24]
IoT	Intelligent and remote treatment of patients using telemedicine devices	[3, 24–26]
	Virtual health data management system that supports decision making	[3, 24–26]

Risk assessment and global public health emergency; searching and collecting data from social and media platforms; production alternatives in manufacturing environments without imposing health risks on workers; robotic treatment in infected patients to prevent contagion; and real-time data to supply medical research and inform the decision-making of scientists and political agents represent outstanding strategies of digital technologies in the fight against the pandemic.

Systems using AR can support a variety of services, providing real-time information to improve decision-making, procedures, and training. Therefore, this technology, in the pandemic scenario, has been widely used due to the need for social distance to reduce the spread of the virus. According to [11], AR enabled the development of medical education programs even during the quarantine period, including the teaching of anatomy, surgical procedures, clinical rotations, interviews with patients, disease presentations, and team training.

The role of this technology in palliative care for people with COVID-19 is also noteworthy, as well as enabling the recording of patients in recent weeks during their lucid moments, resulting in recordings with hologram-type projections that will be sent to family members [16]. Wearables, including AR tools and smartwatches, offer personalized tracking of individuals' health status, extracting surveillance data that facilitates the early identification of disease [2].

AM, also known as rapid prototyping, builds parts based on three-dimensional models designed in software, manufacturing objects layer by layer by adding material through computer-automated processes [17]. Given the outbreak caused by COVID-19, the literature highlights additive manufacturing as a production alternative to support the shortage of critical medical devices, facilitating the efforts of international groups such as the Open Source COVID19 Medical Supplies Group and Hack the Pandemic (Copper3D Inc), providing options to respond to barriers in the healthcare supply chain. The research developed by [18] lists critical open-source medical devices and manufacturers using AM, including the 'H Connector', which allows a single ventilator to be adapted to serve four patients simultaneously for up to 12 h; the antimicrobial NanoHack 2.0 face mask, which can be reused and protects the user during prolonged use; and the Hands-free door opener, which assists the user is connecting to the door handle to prevent microbial contamination.

In managing and combating the COVID-19 disease, collaborative robots are excelling in different applications such as transporting medical supplies, disinfection process, symptom detection, patient monitoring, and providing physical medical support. The study elaborated by [21] also points out the benefits of collaborative robots in medical ventilator production lines, automating almost half of the processes in addition to contributing to reducing the number of working hours of employees.

About logistics, AGVs are being used to make up for the inefficiency of the e-commerce delivery market, which, due to the state of quarantine, had an excessive increase in demand. As an application example, AGVs manufactured by JD operating in Wuhan, China, deliver 24 packages in highly contaminated areas at a speed of 15 km/h [4, 20].

Given that the COVID-19 pandemic is a global emergency, the literature points out that the BDA is at the center of efforts to understand and predict the impact that this

virus will have on the world population. Thus, using trackers capable of extracting information from different sources around the world, a global database is continuously fed to support the decision-making of physicians, scientists, epidemiologists, and politicians. By combining BDA with traditional geographic data, it is possible to identify the main bottlenecks in risk areas, as well as develop dynamic epidemic maps and simulate the transmission process of the pandemic. In the hospital environment, collecting patient data via BDA can link test results to clinical status in near real-time, which helps to accelerate the development of more efficient and targeted treatments to the infected individual, as well as to detect reactions of people who have undergone different medical approaches, facilitating the identification of patterns of contamination and spread of the virus [3, 10].

Since the BDA is an essential tool for managing COVID-19 cases at a global level, the conditions for collecting and processing health data must provide respect for privacy and confidentiality. Extraction of patient data must be scientifically justified and restricted to what is necessary to achieve a specific public health goal. Likewise, governments and healthcare professionals need to carry out transparent public communication about the access and processing of personal data so as not to undermine society's trust [23].

Finally, by having an interconnected network for the effective flow and exchange of data, the IoT is considered an innovative technological platform for the diagnosis and control of the new coronavirus, contributing to telehealth consultations, intelligent tracking of infected patients, real-time data sharing during COVID-19 propagation through the connection of devices, locations, channels, and people, between others. Thus, the IoT automatically captures health data from patients and medical devices and manages it through a virtual management system. The data received is analyzed for patterns or trends, resulting in continuously updated reports that assist in decision-making by healthcare teams in the face of the pandemic [25, 26].

From the application of IoT, COVID-19 Intelligent Treatment and Diagnosis Assistant Program (nCapp) was developed to prevent and control the current pandemic by connecting specialists, primary physicians, and service providers [13]. Also, the development of web-based surveillance tools and epidemic intelligence methods provide a global health monitoring infrastructure via IoT, providing targeted information to health authorities to facilitate risk assessment, help reconstruct the progression of an outbreak and stabilize the economy of the country of origin [24, 26].

5 Conclusion

Technological advances, which form the basis of Industry 4.0, are currently used in manufacturing and are gaining penetration in various sectors of the economy, including the healthcare and medical fields. It was observed that digital technologies are reflecting innovations applied in the face of a public health emergency that challenges systems on a global scale, including AR, AM, AVG, BDA, and IoT. It was found, then, harmonious discussions in the literature regarding the importance of a robust technological infrastructure for the diagnosis, management, and combat of the COVID-19 pandemic, showing the need to foster the development and implementation of digital technologies inside and outside the medical environment through new public policies.

References

1. Valamede, L.S., Santos Akkari, A.C.: Health 4.0: a conceptual approach to evaluate the application of digital technologies in the healthcare field. In: Iano, Y., Saotome, O., Kemper, G., Mendes de Seixas, A.C., Gomes de Oliveira, G. (eds.) BTSym 2020. SIST, vol. 233, pp. 17–24. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-75680-2_3
2. Wuest, T., Kusiak, A., Dai, T., Tayur, S.R.: Impact of COVID-19 on manufacturing and supply networks—the case for AI-inspired digital transformation. Available SSRN 3593540 (2020)
3. Javaid, M., Haleem, A., Vaishya, R., Bahl, S., Suman, R., Vaish, A.: Industry 4.0 technologies and their applications in fighting COVID-19 pandemic. Diab. Metab. Syndr. Clin. Res. Rev. **14**(4), 419–422 (2020)
4. Okyere, M.A., Forson, R., Essel-Gaisey, F.: Positive externalities of an epidemic: the case of the coronavirus (COVID-19) in China. J. Med. Virol. **92**(9), 1376–1379 (2020)
5. Chen, F.-M., et al.: Big data integration and analytics to prevent a potential hospital outbreak of COVID-19 in Taiwan. J. Microbiol. Immunol. Infect. **54**(1), 129 (2021)
6. Melluso, N., et al.: Lights and shadows of COVID-19, technology and industry 4.0. arXiv Preprint arXiv:2004.13457 (2020)
7. Phannajit, J., et al.: Factors associated with the incidence and mortality of coronavirus disease 2019 (COVID-19) after 126-million cases: a meta-analysis. J. Epidemiol. Glob. Health **11**, 289 (2021)
8. Elliot, L.: Prepare for the coronavirus global recession. Guard 15 (2020)
9. Kumar, M.S., Raut, R.D., Narwane, V.S., Narkhede, B.E.: Applications of industry 4.0 to overcome the COVID-19 operational challenges. Diab. Metab. Syndr. Clin. Res. Rev. **14**(5), 1283–1289 (2020)
10. Zhou, C., et al.: COVID-19: challenges to GIS with big data. Geogr. Sustain. **1**(1), 77–87 (2020)
11. Woolliscroft, J.O.: Innovation in response to the COVID-19 pandemic crisis. Acad. Med. **95**(8), 1140–1142 (2020)
12. Zaman, A., Islam, M.N., Zaki, T., Hossain, M.S.: ICT intervention in the containment of the pandemic spread of COVID-19: an exploratory study. arXiv Preprint arXiv:2004.09888 (2020)
13. Javaid, M., Haleem, A.: Industry 4.0 applications in medical field: a brief review. Curr. Med. Res. Pract. **9**(3), 102–109 (2019)
14. Roehrich, J.K., Lewis, M.A., George, G.: Are public–private partnerships a healthy option? A systematic literature review. Soc. Sci. Med. **113**, 110–119 (2014)
15. Plancher, K.D., Shanmugam, J.P., Petterson, S.C.: The changing face of orthopaedic education: searching for the new reality after COVID-19 (2020)
16. Teo, W.Z.Y., BcH, B.A.O., Chai, Y.W.: Virtual reality as a bridge in palliative care during COVID-19 (2020)
17. Larrañeta, E., DominguezRobles, J., Lamprou, D.A.: Additive manufacturing can assist in the fight against COVID-19 and other pandemics and impact on the global supply chain. 3D Print Addit. Manuf. **7**(3), 100–103 (2020)
18. Zuniga, J.M., Cortes, A.: The role of additive manufacturing and antimicrobial polymers in the COVID-19 pandemic. Expert Rev. Med. Devices **17**(6), 477–481 (2020)
19. Yang, G.-Z., et al.: Combating COVID-19—the role of robotics in managing public health and infectious diseases (2020)
20. Shaw, R., Kim, Y., Hua, J.: Governance, technology and citizen behavior in pandemic: lessons from COVID-19 in East Asia. Prog. Disast. Sci. **6**, 100090 (2020)
21. Malik, A.A., Masood, T., Kousar, R.: Reconfiguring and ramping-up ventilator production in the face of COVID-19: Can robots help? J. Manuf. Syst. **60**, 864–875 (2020)

22. Lu, N., Cheng, K.-W., Qamar, N., Huang, K.-C., Johnson, J.A.: Weathering COVID-19 storm: successful control measures of five Asian countries. Am. J. Infect. Control **48**(7), 851–852 (2020)
23. Wang, C.J., Ng, C.Y., Brook, R.H.: Response to COVID-19 in Taiwan: big data analytics, new technology, and proactive testing. JAMA **323**(14), 1341–1342 (2020)
24. Bai, L., et al.: Chinese experts' consensus on the internet of things-aided diagnosis and treatment of coronavirus disease 2019 (COVID-19). Clin. eHealth **3**, 7–15 (2020)
25. Singh, R.P., Javaid, M., Haleem, A., Suman, R.: Internet of things (IoT) applications to fight against COVID-19 pandemic. Diab. Metab. Syndr. Clin. Res. Rev. **14**(4), 521–524 (2020)
26. Rahman, M.S., Peeri, N.C., Shrestha, N., Zaki, R., Haque, U., Ab Hamid, S.H.: Defending against the novel coronavirus (COVID-19) outbreak: how can the internet of things (IoT) help to save the world? Heal Policy Technol. **9**(2), 136 (2020)