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INDUSTRY 4.0 PERSPECTIVES IN THE HEALTH SECTOR IN BRAZIL

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ABSTRACT

Health 4.0 can be understood as the set of procedures that seek to improve the efficiency and speed of health professionals with possible guidelines for combining patient data in hospitals. However, systematizing and qualitatively describing the contributions of industry 4.0 in the context of the Brazilian health sector is a complex task. The aim of this paper is to present an analysis of industry 4.0 related to the health sector and its respective characteristics in Brazil. In addition, it discusses the prospects for greater use of technology in health care.

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In methodological terms, an exploratory field research was conducted with a non-random and intentional sample of professionals working in the technological context of Brazilian health. The research is classified as descriptive and qualitative, exploratory. The results contribute to narrow the information gap about industry 4.0 in the Brazilian health sector. The study allowed to develop a concept map of health 4.0 regarding the professional profile, considering the adoption of technologies that may favor the sector.

Keywords: Industry 4.0; Health 4.0; Brazil

1. INTRODUCTION

Industry 4.0 is based on technology combined with intelligence in data processing (Kamble et al., 2018). The recently proposed concept of industry 4.0 represents the fourth industrial revolution, which is defined as a new level of organization and control over the product life cycle value chain, with an emphasis on customer requirements that become more individualized (Vaidya et al., 2018).

The term appeared in Germany in 2011, through an integration between associations of business representatives, politicians and academic researchers who sought to promote the idea as an approach to strengthen the competitiveness of the German manufacturing industry (Bahrin et al., 2016) and transpose the limits between the digital, physical and biological world (Wegener, 2018).

In health, the principles of industry 4.0 will incorporate the digitization of clinical, medical and laboratory data, implementing the automation of various manual processes used today in hospital and healthcare environments in general (Elhoseny et al., 2018). However, services in the health sector always present challenges as different diseases can develop over the years (Darwin et al., 2017).

Thus, to improve the efficiency and speed of doctors, explore patient data in hospitals, allow the optimization of resources and minimize the deterioration of patient health (Costa et al., 2018), real-time communication technologies (Botta et al., 2016), Big Data, human-machine cooperation, remote sensing, process monitoring and control, autonomous equipment and interconnectivity (Stergiou et al., 2018) are becoming major assets and responsible for positive impacts on health and safety management occupational (Badri, Trudel & Souissi, 2018).

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Current developments in different technological areas lead to new solutions that can provide improvements in the health sector. In Brazil, the health sector is highly fragmented and accounts for R$ 291 billion in business annually. Investments in the Brazilian health industrial complex are mainly focused on patient care, while the information and systems infrastructure tend to play a secondary role.

This is one of the reasons for the low level of interaction between industries and users (Abiis, 2015). Due to the lack of integration between industries and users, innovation in Brazilian hospitals is considered an endogenous factor. This lack of integration is responsible for making access to knowledge produced in universities difficult and for impregnating processes and products with innovations (Barbosa & Gadelha, 2012).

In this context, it is important to highlight the term health 4.0, developed by the Brazilian Alliance of the Innovative Health Industry (Abiis, 2015) based on the characteristics of industry 4.0, which proposes an interaction between technology and human beings in the health sector. In Health 4.0, the possibilities of collaborative partnerships between actors in the same value chain, who can share the coordinated planning of production and distribution, in an agile and effective way to the needs of users, are facilitated.

The works are developed with adequate stocks to the demands avoiding delays or unavailability of products and there is a fast attendance in the demands of the end users and an efficient control in the transaction of the patient data in the hospitals (Abiis, 2015). However, understanding how to digitize data, interconnectivity between machines and commands, more efficient databases and, above all, greater patient autonomy in relation to their own health is a complex task (Brasil, 2017).

Exploring technology-related initiatives that make life easier for human beings will be a stronger trend. This article presents perspectives of industry 4.0 related to the health sector and its characteristics in Brazil through the experience of professionals in the field. As a complement, we seek to verify what are the perspectives for the use of technology in the health area.

It is noteworthy that although the study presents an analysis of industry 4.0 in the health sector, it is not the objective of the research to define rigorously the semantics and syntax of the Brazilian context. The proposed results of the analysis demonstrate which perspectives should be adopted in the health sector, facilitating the dissemination of knowledge regarding

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health 4.0, which can help to characterize the development of a new traditional model for Brazil.

The main contribution of the article refers to the identification of health 4.0 variables, at a qualitative and exploratory level, for the analysis and adaptation of technologies that can be used in hospitals. The propositions and reflections raised in the study also contribute as subsidies for future academic research on the subject, which may continue this initial study.

2. TECHNOLOGIES OF INDUSTRY 4.0 USED IN THE HEALTH SECTOR

Technological innovations have driven the health sector to an unprecedented level. Different medical devices, many of them laptops, are being sold in the consumer market to provide a healthier lifestyle for society (Trinugroho, 2014). Part of the technologies relate to Cloud Computing (CC) and the Internet of Things (IoT). These are platforms that provide alternatives to medical support by solving various problems in health applications, with smart hospitals, control of medicines and remote medical services (Botta et al., 2016; Darwish et al., 2017). In addition, with cyber-physical systems, they can interconnect with a combination of software, sensors, processing and communication technologies that together play an important role in decision-making from the provision of information (Bahrin et al., 2016).

With the interconnection of hospitals, people and systems provide real dynamics with optimized and self-organized time in relation to the patient's condition. Industry 4.0 technologies that have similarities in the use of the health sector should also develop new paradigms on occupational health and safety management, as safer equipment is needed to operate and environments and practices with better control and management (Badri, Trudel & Souissi, 2018). Another technology that should facilitate the exploration of areas that cannot be easily achieved by traditional means of medicine is computational intelligence, which includes simulations of genes and proteins related to the development and immunity of cancer (Chang, 2018).

As in the context of industry 4.0, the literature does not present a unique way to name health technologies 4.0. The classifications used in the literature are often incompatible with each other, as they classify the same technologies into different categories (Almeida, Cavalcante & Fettermann, 2017). Table 1 includes the main technologies that include the principles of industry 4.0 and which are commonly used in the health sector. To facilitate understanding, it was necessary to present the description of each technology to verify its

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function and, from the objective of this article, what seek to improve in hospitals and in the theme of health in general (Silveira et al., 2019).

Table 1: Technologies developed in industry 4.0 used in the health sector.

Authors/Year	Technology	Description	Objective	Countries
Pang et al. (2013)	Internet ofThings (IoT)	Home health services based on IoT to solve problems caused by population aging.	Propose a business-technology developed in co-design that realizes an integration of devices and services of home health attention.	Sweden
Trinugroho et al. (2014)	Internet ofThings (IoT)	Support IOT-based communications between devices and health services in an event-driven manner.	Describe the platform developed, with emphasis on reliability aspects, including availability, scalability and security.	Norway
Catarinucci et al. (2015)	Internet ofThings (IoT)	Identification by radiofrequency, wireless sensor network and intelligent mobile technologies of patients' physiological parameters.	To propose a new intelligent architecture, with IoT recognition, for automatic monitoring and tracking of patients, people and biomedical devices inside hospitals and nursing institutes.	Italy
Zhang et al. (2015)	WearableDevices and Smartphones	Continuous monitoring of health conditions, remotely diagnose phenomena and share health information in real time.	Investigate the security and privacy protection of multifunctional wearable devices and the widespread use of smartphones, including aggregation of privacy data that preserves privacy, secure health data processing, and detection of misbehavior.	Canada
Darwish et al. (2017)	Cloud Computing (CC) e Internet of Things (IoT)	The integration of technologies provides a solution to various problems in health applications, drug control and distance medical services.	Present a new concept of CC and IoT integration for health applications (CloudIoT-Health).	Egypt
Elhoseny et al. (2017)	CloudComputing (CC)	Intelligent systems based on cloud environment for hospital health services.	Improve scheduling of tasks and reduce stakeholder engagement time (patients, doctors, nurses, for example) and maximize resource utilization in clouds.	Egypt
Pramanik et al. (2017)	Big Data e Smart Healthcare	Big Data and Smart Healthcare systems independently attract great attention from the academia and industry and can streamline healthcare industry perspectives.	Evaluate Big Data technologies and intelligent systems focusing on state-of-the-art advanced health systems.	China
Costa et al. (2018)	Internet of Health Things (IoHT)	Intelligent monitoring of vital signs on hospital wings through IoT.	Describe the possibilities of IoT in the scope of vital signs monitoring by hospital wards.	Brazil
Mshali et al. (2018)	Health Monitoring Systems (HMS)	Provide timely electronic health services for individuals who wish to maintain their independence.	Present a review of intelligent health monitoring and health care systems for individuals, especially for the elderly and dependent.	France
Rahmani et al. (2018)	Internet ofThings (IoT)	Develop health solutions with smarter and predictive capabilities for both daily living (home/office) and hospitals using IoT and the strategic position of such gateways.	Explore the concept of Cloud Computing in Healthcare IoT systems, forming an intermediate layer of intelligence distributed geographically between the sensors and the cloud.	USA

Source: Adapted from Silveira et al. (2019).

There are other devices, such as wearable products that are developing widely and can be used to provide continuous medical care, such as monitoring physiological parameters for health care through monitoring (Liang et al., 2012).

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These are wristwatches, wristbands, rings and smart hair covers that fall within them as ubiquitous products and use mobile networks (WIFI) and computer servers that are responsible for collecting health information detected by such products (Wang et al., 2010; Liang et al., 2012; Zhang et al., 2015). In addition, they process the data to properly monitor and diagnose integrity and allow social interactions with users, so that errors do not result (Carnevalli, Sassi & Cauchick, 2004; Toninelli, Montanari & Corradi, 2009; Zhang et al., 2015).

3. METHODOLOGY

A research has a qualitative approach. To achieve the objectives of this study, an exploratory field research was conducted, with an unransom and intentional sample (Carnevalli, Sassi & Cauchick, 2004). As this sample was not probabilistic, it is not possible to affirm that it is representative of the current situation of the country in the context of health 4.0. However, it is worth mentioning that as criteria for the selection of professionals and business consultants in the health sector, similarity and experience in the field of knowledge of the research were considered.

In addition, the purpose of the sample is to produce in-depth and illustrative information: whether it is small, what matters is that it is able to produce new information. Through field research, it is possible to verify the health sector and its characteristics and also provide an exploratory view on a subject where the relevant variables are not yet fully determined and the phenomenon is not completely known.

Data collection was performed based on an open questionnaire and the results obtained in the research underwent an analysis process. The questionnaire used was divided into ten questions. Its structuring was based on the Brazilian health sector. Regarding the characterization of the health sector, we sought to identify different opinions on the impacts of industry 4.0 on health, the prospects for the use of technology in the health area, the challenges of industry 4.0 in the country (in addition to the health sector), the impacts (technicians, economic) that will be absorbed by customers (patients) due to the incorporation of new technologies and devices in health 4.0 and the health professional 4.0.

In order to maintain the confidentiality of the participants, numbering was used to characterize them. To analyze the information, the answers were encoded and the data were tabulated in order to interpret the particularities of each participant. The questionnaire was applied through the use of a digital platform (Google Drive), facilitating file storage and formulating questionnaires using the internet as a means to apply them to respondents. Thus, it

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is only required from the e-mail address (e-mail) of the person responsible selected in the study to submit the questionnaire. This was performed with two participants in the research, because they did not present availability of time for interview and lived in cities far from the site of the interviews.

CmapTool was adopted for data analysis. It is a tool used to develop conceptual and graphically represented schemes, constituting a program that helps to design concept maps. Help in the organization and representation of knowledge. The concepts displayed in the boxes and the participants between them are identified by means of connecting phrases that are each of the concepts.

4. RESULTS AND DISCUSSIONS

4.1. Characterization of respondents and impacts of Industry 4.0 on health

All interviewees are male and Brazilian nationality. Two are medical professionals, with a doctoral school level and currently work in the context of digital innovation in hospitals. The other two interviewees are consultants in the health sector. Table 2 shows the other information of the professionals who contributed to the development of the research.

Table 2: Characterization of professionals who contributed to the research.

Interviewee (I)	Profession	Education	Gender
1	Health Sector Consultant	University Graduate	Male
2		PhD	
3	Medical		
4			

According to I1, the impacts of industry 4.0 in the health sector are related to the increased availability of products and services to meet health needs, especially through product differentiation and adaptation to the characteristics of each patient, characterizing a medicine precision or personalized medicine. This theme has been corroborated in several researches, such as research that affirms that the fusion of technologies is not just a product of science and engineering, but is a product of values and institutions (Jayanthi et al., 2019). Work within hospitals must be articulated with industry, government and universities to create a joint vision of the future.

I3 added that other positive factors will be provided, such as efficiency and speed in diagnoses and hospital procedures, new alternatives for transplants, such as 3D printing, and finally, real-time integration of services, from primary care to cases of discharge. complexity. Analyzes by artificial intelligence, interconnectivity of platforms, predictive models in patient

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health are changes that are developing and affect people directly. The ability of algorithms to process and transform available data to make accurate predictions about disease classifications, resource optimization and cost reduction are already used in some hospitals, especially in developed countries (Brown-Martin, 2017).

I4 and I2 emphasized that these changes open the door to a model with better traceability and transparency in the care offered to patients. It is noteworthy that with the integration of data and technologies, better results for the patient and cost reduction throughout the health chain should occur. In fact, machine learning algorithms have made it possible for forecast quality to improve according to experience, that is, the more data, the better forecasting mechanisms are created (Jayanthi et al., 2019).

4.2. Description of Health 4.0 in Brazil

According to I3 and I4, there is still little incentive for the creation and adoption of new technologies in educational institutions, mainly due to the lack of economic and government incentives and because Brazil has a highly bureaucratic system. The economic incentive for the adoption of new technologies in the scope of health 4.0 is fundamental, as well as government support and partner institutions, however, this has not been characteristic of governments in underdeveloped and emerging countries (Park, 2016).

The latter are slowly waking up to the health benefits 4.0 (Almeida, Cavalcante & Fettermann, 2017). For I3, another aspect is compliance with traditional management models, resistance to computerization with real-time data sharing. Brazil has the potential to be a great developer of interaction platforms for health, connecting data, equipment and health professionals, but for this to happen it is necessary to act in the organizational culture (Almeida, Cavalcante & Fettermann, 2017).

For I2, there are four major barriers to be overcome in general. The first is strategy - today, company leaders are rewarded for thinking in the short term, about generating rapid increases for their shareholders, so long-term planning is not a priority. The second addresses social aspects - industry 4.0 is seen as something that will generate impacts such as the change in jobs and business models, but the proposal is far from participating in this change.

The third barrier refers to the process of training and skills development - there is no urgency to demand or facilitate the training of people with the knowledge that will be required. The fourth is technology - most companies are not prepared for changes in paradigms, especially in organizational culture.

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The health sector regulations are emphasized, which are neither political nor protectionist. For I1, the professional health class society treats the subject of technologies as a problem that will harm the doctor-patient relationship. However, for I3, the technological evolution in health will bring integration, process improvement, avoid waste and better treatments for patients.

It also adds that doctors and health professionals will have to evolve together. If disruptive technologies are inevitable, they must also be directed to health, in a qualified and applied manner. I2 and I4 state that technological innovation in health comes to add to the professional and the patient, not to compete. According to them, the theme will not be just health but the life of the human being as a whole.

For I2 and I3 in relation to the treatment of diseases, intelligent systems can suggest effective ways and also improve prevention. According to them, health professionals should make use of sophisticated machines and have access to a large amount of organized data, contributing to a decision making process with less likelihood of errors. The information ends up being used only reactively.

For all respondents, based on an extensive relationship between patients, their illnesses and treatment targeting, it would be possible to identify better treatment alternatives for each type of patient based on analytical models. Finally, they add that accessing a complete medical history would allow understanding of predecessor treatments and their relationship with future ones. Everything is a matter of understanding the patient's need and what the information leads us to conclude. Figure 1 presents the conceptual map of the health sector 4.0 in Brazil.

Patient data is collected manually in hospitals from autonomous medical devices, including vital signs (Costa et al., 2018). Such data are sometimes stored in electronic spreadsheets, not being part of the electronic medical records of patients, and therefore it is difficult for those responsible in the hospital to combine and analyze them. Thus, a solution to overcome these limitations is the interconnection of medical devices via the Internet using a distributed platform, the IoT. This approach allows data from different sources to be combined to better diagnose the patient's health status and identify possible anticipatory actions (Costa et al., 2018).

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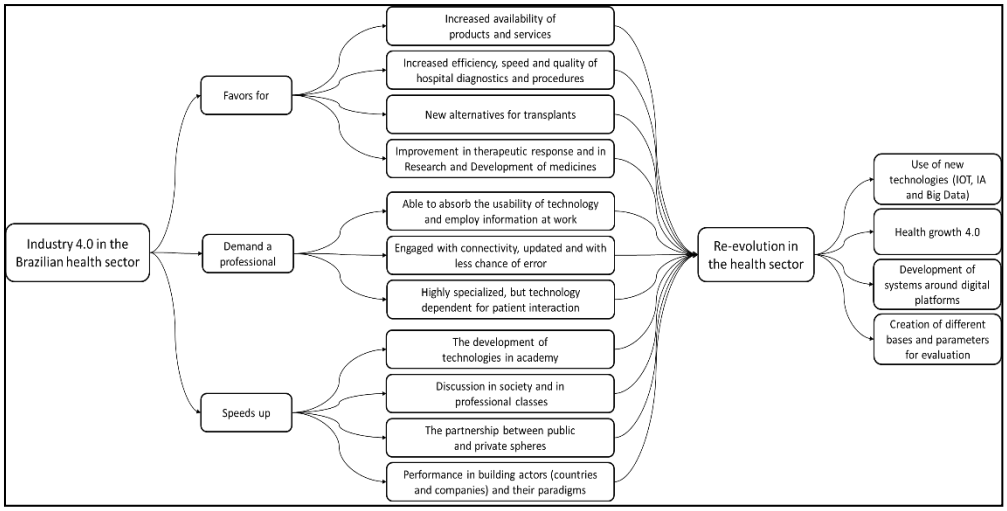

Figure 1: Conceptual map of the Brazilian health sector 4.0 based on respondents.

The adoption of CC and IoT in the health field can improve health services and contribute to continuous and systematic innovation in a Big Data environment as applications in industry 4.0 (Elhoseny et al., 2018). However, the resources needed to manage this data in the Cloud-IoT environment are still challenging. Figure 2 shows the technologies that should be used in the context of health 4.0. The illustration was prepared using data from interviews with professionals in the sector. Note that different technologies that together make up health 4.0 have been exposed.

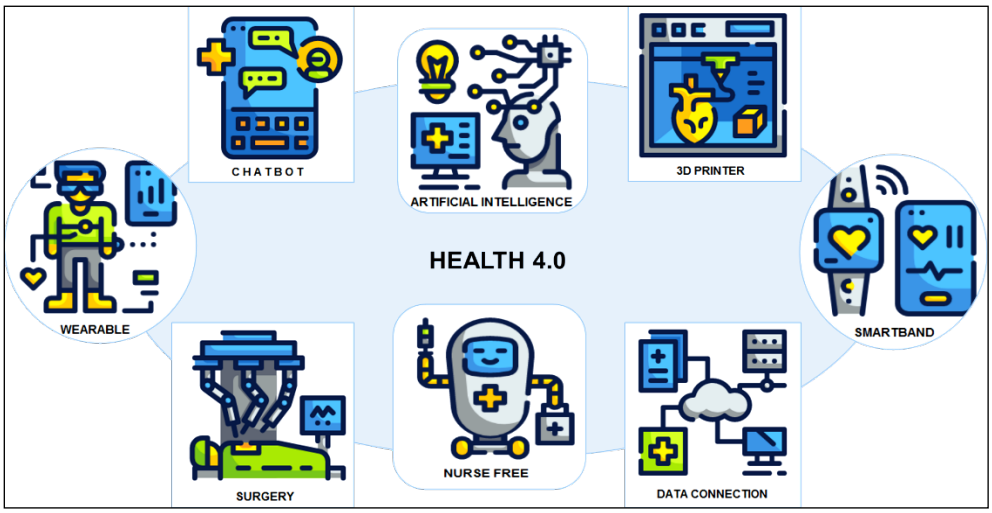

Figure 2: Technologies that characterize health 4.0.

The technologies in Figure 2 are already present as technological improvements in some hospitals. They are responsible for managing the large amount of data through intelligent management systems, constantly monitoring the patient with the IoT interface. New innovative techniques have emphasized the offer, with long-term gains in efficiency and productivity. Transport and communication costs must be reduced substantially, logistics and global supply

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chains tend to become more effective, and commercial costs will decrease (Klaus, 2016). In addition, connectivity and information analysis are the main pillars of this transformation (Jayanthi et al., 2019).

Connectivity because the patient will be able to carry all his medical history with greater data security, which is allowed by block chain, the same that made Bitcoin one of the safest virtual currencies today. And with information analysis because an artificial intelligence can process information much faster than a human being. This repetition of comparisons allows the assessment of causalities to preventively respond to a patient at risk. Being able to understand the variables that signal a higher risk for the patient is only possible with this intelligence in hand. It is also noteworthy that in Brazil there are currently archaic electronic medical records and backward management systems that do not talk and with the technological evolution of health 4.0 there will be a standardization of languages and integration.

5. FINAL CONSIDERATIONS

The objective of this article was to present perspectives of industry 4.0 related to the health sector and its characteristics in Brazil through the experience of professionals in the area. As analyzed in the research, in the health sector, health technologies that embrace the principles of industry 4.0 should be adopted to improve data digitization, interconnectivity between machines and commands, more efficient databases and, mainly, greater patient autonomy in regarding their own health. The main technologies identified in the interviews refer to CC and IoT developed for hospitals, as they seek to support communications between devices and health services.

In addition, the article contributed to health professionals who seek to better understand the definitions and concepts related to health 4.0, also providing, for researchers and interested parties, a study on the topic. The description of the results was focused and critical, structured, as far as possible, for the expansion of knowledge about industry 4.0, given its topicality and relevance in the health sector, which are necessary to interconnect hospitals, people and systems to provide real dynamics with optimized time and self-organized regarding the patient's condition.

The main limitation of the research is related to the collection of data through a restricted number of respondents. A broader proposal by participants from the health sector 4.0 in the survey could be developed to verify new useful information about the context under analysis. As future steps, it is suggested to carry out research that deepens the field of health

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knowledge 4.0, such as: i) analyzing how developed countries are promoting the health value chain 4.0; ii) verify how product development by Brazilian companies in the health sector should be in the coming years; and iii) identify how smart hospitals are empowering employees, while new technologies are being developed annually to control patient data.

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