Industry 4.0 In Modern Patient Management

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Abstract

The fourth industrial revolution is marked by new technologies that favor not only the business sector but also the human being himself, which is why it has gradually spread to all sectors of knowledge, as is the case of the health system, which requires constant research to advance for the benefit of humanity. Telemedicine is part of the progress of the health sector, where it was not conceived that there could be remote assistance in patient care; part of the inclusion of this model of medical care has been the social factors such as the COVID-19 pandemic that forced human beings to live in isolation to survive, which forced to attend those chronic patients who require remote monitoring, making use of the technological advances that society offers us. So with this researched article, we seek to describe the contributions of industry 4.0 through applications in big data, the internet of things and artificial intelligence that have been developed in favor of telemedicine, allowing this to have a better control on the patient, to prevent health situations or attend them more efficiently; from a literature review of articles and success stories.

Keywords: Big data, internet of things, industry 4.0, health 4.0, telemedicine.

Introduction

In recent years, the world has been undergoing accelerated changes marked by information technologies and these have permeated all economic and social sectors, so much so that they have been introduced into the privacy of human beings and transformed personal relationships, as well as keeping science in an investigative role aimed at the innovation of productive processes and systems Montero, et al ;(2019).

Industry 4.0 has marked a paradigm shift because it involves information technologies with manufacturing technologies to revolutionize the character of the human-machine relationship; the fourth revolution of industry integrates physical, digital and biological systems so that they interact and collaborate with each other and modify the way humans interrelate with the world Beier,(2022).

The concept of industry 4.0 is relatively new, it was first given in 2011, at the Hanover Fair in Germany, and coined to smart manufacturing; later, by 2013, the German Government, presents the document "Recommendations for implementing the strategic initiative industrie 4.0" Working Group,(2013) with the aim of setting a guideline of initial conditions for implementation in German industries.

Later this concept became popular worldwide and refers to the Fourth Industrial Revolution, which is based on the digitization of industrial systems and processes and the relationship with information technologies to make production processes more flexible. Figure 1 shows some of the technologies used in industry 4.0 which are the internet of things, big data, 3D printing, artificial intelligence, mobile technology, cloud computers and cyber physical systems Saturno, et al;(2018).
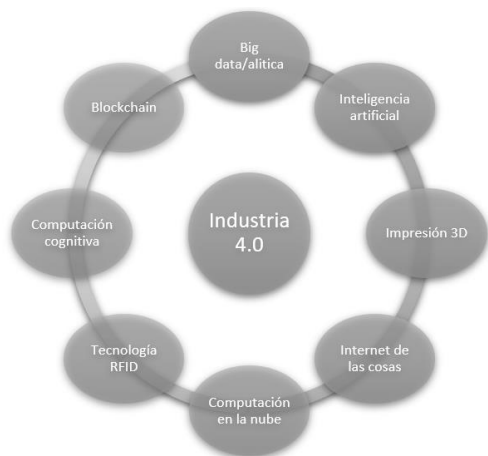

Figure 1. Industry 4.0 Technologies

The 4.0 technologies are based on cyber-physical systems where communication, computing and control are integrated; within these 5 technological pillars stand out, the Internet of Things (IoT) which are technological objects such as cell phones, sensors, computer equipment linked together. Cloud computing, which is the online storage of information that can be used in an unlimited way and from any point. Big data, which are databases that serve as analysis or collection of information to be processed. Artificial Intelligence which is the development of machine intelligence through algorithms and robotics. Blockchain which is the blockchain that makes use of cryptography Quintero, D,(2020).

All these technologies are part of the advancement of communications and the way in which information is available; every day man depends more and more on information technologies to facilitate personal and work relationships, and has led the same human being to explore all the uses of technological advances in production systems, whether or not they displace labor, advances continue to occur and benefit businesses, education, science, health and almost all areas of knowledge development. The health system worldwide is one of the challenges of all governments in the social and economic aspect, which demands new and advanced solutions in science and technology, which is why for two decades information and communication technologies have impacted access and improved the efficiency and quality of health service delivery Garcia, el at; (2022) and with this was born the term e-health, understood as the application of ICTs in health and has been the subject of research and scientific investment.

The term e-health has undergone connotations and transformations over time; with the fourth industrial revolution all economic sectors have been impacted, and one of the most involved is the health sector, which has been implementing innovations with information and communication technologies, allowing to provide a better service to patients Lindberg & Lundgren,(2022) ; and the concept of health 4.0, which is nothing more than a management model for health care inspired by industry 4.0, which allows to personalize medical care almost in real time through cyber-physical systems and the technologies of industry 4.0 through virtualization, providing personalized and accurate diagnoses Bause, et al;(2020).

The concept of health 4.0 is becoming familiar among health professionals, and one of the factors that

took this concept to another level was the COVID-19 pandemic, accelerating the implementation of research that was in the testing phases to facilitate and protect the health of all due to the health emergency Basset,et al;(2021). From the health personnel, virtual reality was applied to be trained and not to be exposed to contamination, robotics was used to provide treatment to infected patients and medical care was strengthened through information technologies, known as telemedicine Ahmad, et al;(2022).

Telemedicine is remote medical care, and it is a technology that can be beneficial to have a preventive treatment and favor long-term health; it is assertive for those people who for regional causes do not receive quality treatment, and avoids acquiring infections by being in closed places with patients with other pathologies waiting for a face-to-face appointment. Initially it started with a telephone call or a videoconference, but telemedicine goes further with the use of other Q technologies. Ma, et al;(2022).

Telemedicine is being applied more frequently, but its implementation has been slowed down because remote patient care does not allow medical personnel to check vital signs, measure blood pressure and blood sugar levels in real time, or assess the patient in person to palpate the heart rhythm or other body organs.[12]telemedicine is not selected by the patient as the best option because it is not able to make a diagnosis in real time.

This is why remote medical care requires Industry 4.0 and information technologies for its performance; telemedicine facilitates the health service for those people in rural areas who must go to the city to see a specialist, or those who can hardly leave their work routine to go to an appointment in person; but all this must be knotted to a technological literacy, because not all humanity has access or knowledge of how to handle a device, or has access to the internet to achieve the virtual connectivity required Shee, et al;(2022).

Regarding literature research related to this, the one by Aceto, et al Aceto,et al;(2020) stands out, which makes a tour of the concepts of e-health and health 4.0 highlighting the benefits of implementing big data, internet of things and cloud computing and the challenges that the health sector shows in this aspect. Research on industry 4.0 in medicine is more abundant in English and it is a trending topic due to the health emergency, so the studies shown are more focused on the treatment of the COVID-19 virus. Regarding Telemedicine specifically no study or bibliographic compilation is shown since it is a branch of medicine little explored by medical personnel and was mostly adopted by world conditions, besides it is a field that requires ICT's to be developed which implies that it goes hand in hand with industry 4.0 for its implementation.

This research aims to highlight the contributions of industry 4.0 that have been made to telemedicine, proposed or implemented, from the different technologies of this industry; conducting a literature review, compiling research articles that favor the provision of health services under this modality, regardless of the region or country, taking into account the technologies of industry 4.0 that apply to the health sector.

The aim is to contribute to the research of a topic that is a worldwide trend and to provide valuable information for future research and in Spanish, where there are few scientific articles.

Method

The research consists of a literature review of indexed and approved publications, with the aim of describing the research contributions that have been generated in telemedicine since the fourth industrial revolution. The databases used for consultation are Sccience Direct, Researchgarte, Google Scholar, Web of Science (WOS) and PubMed and documents such as journal articles, conferences, textbooks and reports of institutional bodies.

Figure 2 shows the databases consulted in this research according to the references collected, PubMed is a database specific to medicine, and was of great support to focus on the topic, Science direct is the database that most contributed articles to this research, since it offers more open access articles.

The Web of Science database offers a list of open access journals, which made it possible to find specific journals on the subject, consulting the different volumes according to the articles; on the other hand, Researchgate is a database that shows more open access research, which is sometimes limited on the science direct platform, thus allowing access to titles that are not available in other databases.
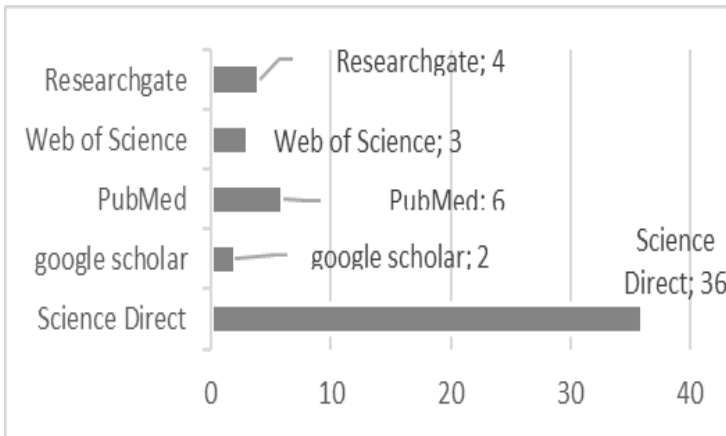

Figure 2. Databases consulted in the investigation

The search was carried out using the following keywords: industry 4.0, telemedicine, big data, internet of things, artificial intelligence; one or several terms in Spanish and English were combined, using different equations to obtain more precise results. Per database, 50 articles were extracted as a basis for research. The methodology applied for the proposed research contemplated the phases of collection, detection, consultation, taking into account the summary, key words, introduction and conclusions of the references. Information related to theoretical bases of industry 4.0 and telemedicine, applications or programs proposed or implemented was extracted Fernández & Baptista ;(2014).

In order to have an updated research, the bibliographic references consulted were from the last five years, i.e., between 2017-2022, and were classified according to the year of publication, where the year 2022 is the highest scientific contribution, followed by the years 2021 and 2019 as seen in Figure 3, therefore, it is a research with recent information.
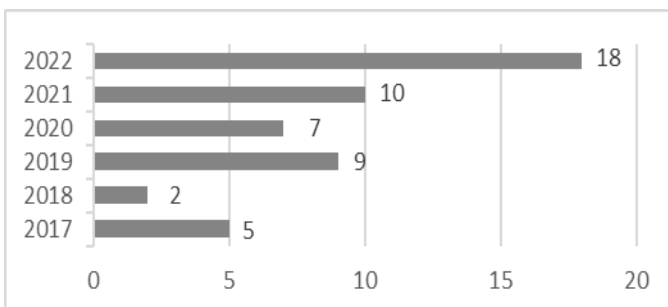

Figure 3. Research references by year of publication

Results

Based on the bibliographic research, the articles that contribute to telemedicine were compiled and are described in the following table, according to the technology applied or proposed.

Table 1. 4.0 Technologies Used In Telemedicine

Author	Technology	Application
A. B. Teixeira *et al*	Internet of things	Optimization of reperfusion therapy
S. Mehta *et al*	Big data	Heart rate data
H. Faris, M. Faris, M. Habib, and A. Alomari	Artificial Intelligence	Common symptoms automatically-application Altibbi
D. Mrozek, A. Koczur, and B. Małysiak-Mrozek	Internet of things, artificial intelligence	Adult fall detector
S. T. Ahmed, M. Sandhya, and S. Sankar	Artificial intelligence	Biomedical signals from organs in telemedicine
Md. S. Rahman, N. T. Safa, S. Sultana, S. Salam, A. Karamehic-Muratovic, and H. J. Overgaard	Internet of things, artificial intelligence	Digital system to identify COVID-19 or dengue fever in a timely manner
N. Sharma *et al*	Internet of things	Early detection of COVID-19
N. al Bassam, S. A. Hussain, A. al Qaraghuli, J. Khan, E. P. Sumesh, and V. Lavanya. Lavanya	Internet of things, information in the cloud	Device for monitoring vital signs of quarantined patients
R. J. S. Raj, S. J. Shobana, I. V. Pustokhina, D. A. Pustokhin, D. Gupta, and K. Shankar	Internet of things, artificial intelligence	Medical image sorter
A. Almeida, R. Mulero, P. Rametta, V. Urošević, M. Andrić, and L. Patrono.	Internet of things, big data	Monitoring of elderly people
K. C. Okafor and O. M. Longe, "Smart deployment of IoT-TelosB.	Internet of things	Streamrobots for remote medical assistance
C. Li, X. Hu, and L. Zhang	Internet of things	Heart disease monitoring
V. V. Garbhapu and S. Gopalan	Internet of things, information in the cloud	Vital signs monitoring
R. Zhou *et al*	Information in the cloud, internet of things, big data	Hypertension monitoring
Y. Guo *et al*	Big data	Mobile Atrial Fibrillation Application (stroke prevention)
J. Peng, Y. Huang, K. Yu, R. Fan, and J. Zhou	Internet of things, big data	Fetal monitoring in pregnant women
A. E. Gîstescu, T. Proca, C. M. Milut, and A. Iftene	Big data, internet of things	Cross-platform application for monitoring
E. C. Moser and G. Narayan	Artificial intelligence	Breast cancer predictive tool
Z. Nikniaz, Z. A. Namvar, M. Shirmohammadi, and E. Maserat	Internet of things	Mobile application with celiac diet
A. Vipin Das, R. C. Khanna, N. Kumar, and P. Kumari Rani	Information in the cloud, internet of things	eyesmart application for telephthamology care
Y. C. Chen *et al*	Artificial intelligence	Diagnosis of middle ear diseases
S. Thainimit, P. Chaipayom, N. Sa-arnwong, D. Gansawat, S. Petchyim, and S. Pongrujikorn	Artificial intelligence	Early glaucoma detection by teleophthalmology
M. Mathai *et al*	Artificial intelligence	Telemonitoring of visual acuity
L. Albert, I. Capel, G. García-Sáez, P. Martín-Redondo, M. E. Hernando, and M. Rigla	Internet of things, artificial intelligence	Mobile application for gestational diabetes mellitus management

A. Jain *et al*	Artificial intelligence	Tool for the diagnosis of skin conditions by teledermatology
M. L. Morales-Botello *et al*	Big data, internet of things, information in the cloud	Remote monitoring system for chronic patients
A. Croatti, M. Longoni, and S. Montagna	Internet of things	Remote stroke diagnostic application
A. Kikuchi *et al*	Internet of things	Telerehabilitation platform for patients with heart failure
O. Taiwo and A. E. Ezugwu	Internet of things	Monitoring of patients in isolation
L. Brunese, F. Mercaldo, A. Reginelli, and A. Santone	Blockchain - cybersecurity	Protection of health systems

Implemented within the health system; the scientific articles taken as a basis are quite updated, since due to the health emergency the medical staff and science accelerated the research of tools that would allow covering the health service despite the isolation, and telemedicine was the methodology that was applied to medical care, but the need to be supported by technology to be more efficient in diagnoses is seen.
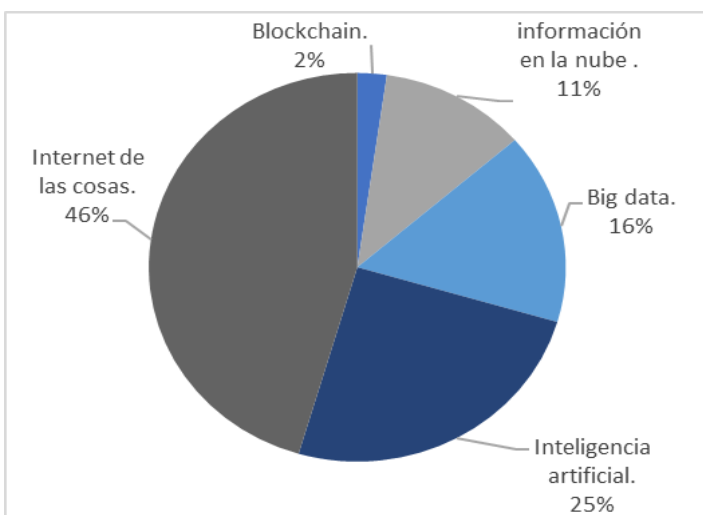

Figure 4. 4.0 technologies applied in telemedicine

Figure 4 shows the most applied technologies in telemedicine according to the references collected, where it is highlighted that the most common is the internet of things, because it is necessary to transmit information through sensors and / or applications remotely to the patient's doctor; But others are also implemented to complement or improve the application or technological tool, such as artificial intelligence, which by means of the applications generates a diagnosis according to the results of the patients, without the need to be evaluated by medical personnel; this makes the diagnosis more accurate, allowing doctors to design the appropriate therapy for the patient. The case of the information in the cloud allows archiving or compiling the daily monitoring and activity of each patient and thus being able to show a history to the treating physician, giving a better control follow-up to vital signs, for example.

According to the tool resulting from technology 4.0 applied to telemedicine, it is highlighted in Figure 5 by area of performance and it is evident that the branch of ophthalmology has made use of technologies to attend their patients remotely and thus prevent visual problems, likewise it is shown that the most common applications are for monitoring signs remotely, either because the patient is in isolation or because it is a chronic patient suffering from diabetes, hypertension or heart failure, which allows medical staff to show a history of the measurements more accurately, because these take signs at different times where they are taken in different areas, hypertension or heart failure, which allows medical staff to show a history of the measurements more accurately, because these take signs at different times where

the patient may be exposed to other situations, while if the patient goes to a consultation in person, only the pressure is taken at that time and the person may be very agitated by the rhythm of the day.

The Cardiology area has also benefited from this technology and can also attend remotely, since it not only allows to generate a diagnosis but also to prevent a stroke or heart failure, because it alerts the medical staff so that the patient can go in a timely manner to an emergency for a medical procedure or have a medical prescription to improve their health condition.
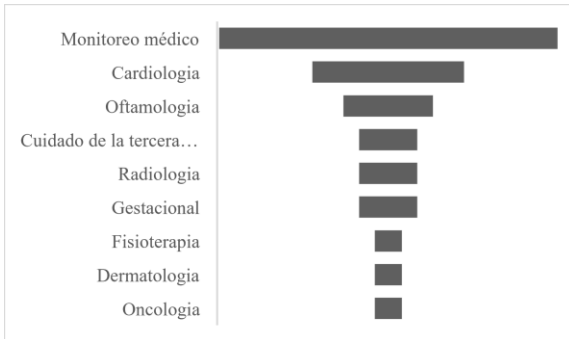

Fig. 5 4.0 Technology 4.0 application areas

Discussion

Although health 4.0 still has a long way to go in terms of implementation worldwide, there is already mention of a new era in the countries with the most progress in the sector and it is health 5.0, the era of intelligent disease control and detection, marked by sensors, nanotechnology, drones, network 5.0, robotics and industry 4.0 technologies. Health 4.0 also faces social and organizational challenges and the lack of a legal framework and regulatory public policies in digital health, as well as technological barriers either due to lack of access to them or lack of knowledge of how to use them, so its implementation must be resilient and be considered in the public budgets of all nations Saraswat,et al;(2022).

On the other hand, the health emergency led users or patients to make use of mobile applications to have medical care and prevent diseases, as well as those who must be regularly monitored. This was a constant of use for reasons of isolation, currently the frequency of use of these applications is more reduced, which implies a greater effort by the state and health entities to enrich these platforms and socialize them in a better way with the population Lu, et al;(2022).

In Europe, a study revealed that most of the mobile health applications have been designed for the care of older adults with multimorbidities Melchiore,et al;(2022), which indicates in the first instance that in developed countries access to information technologies is broader, and technological literacy is greater in the population, since an older adult can easily access these resources. Secondly, Industry 4.0 has permeated all age groups and has made life easier for many people by offering advances in health control and prevention.

Within Industry 4.0, blockchain technology is considered, but according to the search of articles, it was found that this technology supports others, but does not work alone, since its objective is to provide security to the data passing through an internet connection or in the cloud. It implies that it designs programming for the cybersecurity of information, which provides users of information technologies with the guarantee that the information provided is private and will not be used by cybernetic intruders or hacked with malicious intentions Clim,et al;(2019).

In the case of Latin America, research is limited and in the field of application, there is progress in the

provision of the service, but the challenge in this region of the world is to cover the provision of the service to the entire population, because there are major obstacles in this, either because the rural areas are larger or because corruption has led to little progress in technological means in the health sector. Medicine is not yet a right that every citizen should enjoy, but to have access to quality medicines and quality service, one must pay for it; all these factors mean that telemedicine is little or not applied, it was used during the pandemic situation, but currently the service has been resumed in person, besides the fact that culturally patients still rely more on the diagnosis of the doctor by experience than on a machine programmed for this purpose.

One of the shortcomings shown worldwide is that a large part of the world's population does not attend medical check-ups in a preventive manner, and due to the saturation of the system they turn to technological means to get information or self-diagnose and take natural or traditional medicine recommendations through the experiences of other people or by searching the internet, and they ignore the knowledge of the medical staff, which sometimes works or sometimes aggravates the disease or diagnosis they are suffering from. One of the most time-consuming areas of medical care is oncology, and the staff is sometimes scarce for the amount of activities, as well as the personalized accompaniment of each patient who, although they have the same diagnosis, the medications are not formulated in the same way because they depend on gastric conditions and other individualized aspects, which is why it is necessary to personalize the service. Here where artificial intelligence helps and specializes this area of medicine, since this technology has been assertive and in addition to this, telemedicine has favored those patients in delicate conditions that do not allow the transfer Kamei,T;(2022)

Conclusions

By way of conclusion, information and communication technologies have been gaining space in society, and currently the human being assumed them as their own; this has led science to keep in constant development to innovate and meet the needs of consumption; this brought the fourth industrial revolution, making use of the tic's in the productive system and specializing the activities within organizations, today, a manager could know where his merchandise travels and in which store is exhibited; in the case of health, the progress has been towards the inclusion of these technologies 4.0 technologies in the provision of services, and one of the most benefited methods with these tools is telemedicine, achieving through it to reach those patients who live in rural areas or areas of difficult access, where the internet reaches any person can make use of telemedicine.

A smart cell phone through different applications can measure the heart rate, blood pressure, the number of calories consumed and burned during the day, can identify if you are an active person or do physical exercise or is a sedentary person, can recommend a diet according to your lifestyle, or maybe even analyze whether you need glasses or not; All this is possible, only with a device, and it is the same one that medical personnel and science use to generate a control over the patient, which allows them to be more accurate in the diagnosis and therefore in the prescription of a drug.

The internet of things as technology 4.0 is one of the most applied in telemedicine with 46% of participation, because it allows to generate a constant monitoring of the patient through sensors and transmitting this through the internet, this greatly facilitated life in times of pandemic, both at the level of the patient and at the medical level, since those medical personnel who were exposed to contamination by the virus, could control an infected patient remotely, without having to come into physical contact with the patient, On the other hand, the elderly also benefit from this technology, allowing them to live a safer and more pleasant life, because it facilitates geriatric care, by preventing falls according to the patient's body movements.

The least used technology is Blockchain, since it offers cybernetic security to the different applications,

being more of a complement than a tool that operates alone; it makes use of cryptography and allows safeguarding medical information effectively to prevent data theft. Among the areas of application of Industry 4.0 in telemedicine are programs or systems for medical monitoring of signs, which remotely provides medical personnel with a history to make a better diagnosis. Cardiology also makes use of these technologies with the aim of preventing cardiac accidents that can be prevented with a quick and timely reaction, collecting information on the health of the heart.

However, the level of trust of patients and health personnel in information technologies is still medium [50], because although technological tools are available, the patient feels more comfortable when the physician attends him/her in person and there is physical contact, a situation that makes trust greater, either because of experience or because of the reputation gained in being assertive; as for medical personnel, the level of trust differs due to the programming of the technologies.

Future lines of research for this study could include the advancement of regulatory laws on the provision of health services through telemedicine; or the sectorization by region of the contributions and applications of telemedicine in terms of 4.0 technologies.

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