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REVIEW ARTICLE

HEALTH 4.0 AND HEALTH 4.0 TECHNOLOGY APPLICATIONS

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Abstract

Health 4.0, which has developed with Industry 4.0, has started to become extremely important in terms of the health sector and health management. Today, health institutions that do not implement Health 4.0 technology applications are lagging behind in the field of health. Now, patients who receive or want to receive health services attach importance to the technologies used by the health institutions they will receive service from and prefer health institutions that have these technologies. It would be a correct approach to talk about a customer portfolio that is aware of the existence of technologies related to health care and uses them. For this reason, in our study, Industry 4.0 and previous industrial revolutions, which contributed to the emergence of Health 4.0, were mentioned first, and then Health 4.0 and, of course, previous health revolutions related to health were continued. Then, the Health 4.0 technology applications in the Health 4.0 period, which are more used, are explained, and finally, Society 5.0, which has started to become widespread today and is foreseen to exist in the future, is explained and our study is concluded by explaining how it is already integrated into the health field.

Keywords: Industry 4.0, Health 4.0, Technology Applications, Society 5.0

1. INTRODUCTION

Today, with Industry 4.0, technological development has begun to be given importance in many areas. Healthcare is one of these areas. For this reason, the technology revolution of today, which we call Industry 4.0, has also affected the Health 4.0 revolution in the field of health. Of course, as in Industry 4.0, Health 4.0 has passed through various phases until today. These phases are Health 1.0, Health 2.0, and Health 3.0.

Of course, with Health 4.0, various Industry 4.0 applications have started to be developed and implemented in the field of health. Technological applications that emerged in the Industry 4.0 era such as artificial intelligence, cloud computing, machine learning, big data, cyber-physical systems, blockchain, and the internet of things have evolved into the field of health and started to be used in the period we define as Health 4.0.

The application of the aforementioned technologies in the field of health leads to positive developments and changes. Thus, healthcare professionals can quickly recommend diagnosis, diagnosis and treatment for patients by avoiding health-related problems thanks to the technological applications found in Health 4.0. Patients also get rid of negative conditions such as the progression of their diseases, as well as quickly regaining their health with early diagnosis, diagnosis and treatment methods.

With Health 4.0, not only early diagnosis, diagnosis and treatment, but also health-related inventions gain importance. New inventions in health are becoming an important phenomenon that will reduce human deaths and prevent the spread of diseases. In addition, with Health 4.0 technological applications, patient records are kept securely and they are used when necessary.

In addition to all these, Society 5.0, which is thought to be a transition after Industry 4.0 and whose effects are starting to be seen, also causes developments in the field of health, and it is obvious that these developments in the field of health will increase even more.

2. INDUSTRIAL REVOLUTIONS

Until today's Industry 4.0 stage, Industry 1.0, Industry 2.0 and Industry 3.0 periods were passed. Figure 1 below shows the development in the Industry 1.0, Industry 2.0, Industry 3.0 and Industry 4.0 periods..

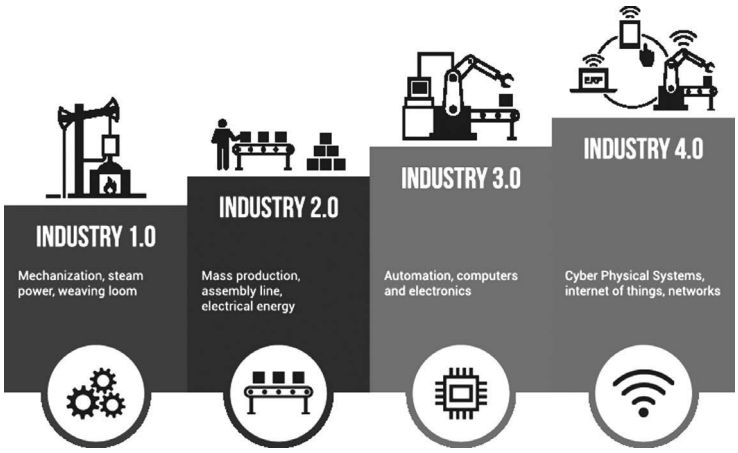

Figure 1. Industrial Revolutions (Kucera et al., 2018, 57)

1.1. Industry 1.0

With the transition of people from the communities where they make a living by hunting and gathering to the communities where they make a living by farming and stockbreeding, the transition from small settlements to urban life has begun. However, the first industrial revolution was not experienced in this period. With the invention of steam engines in the 18th century, the first industrial revolution, the Industry 1.0 period, began.

This period, in which the individuals' manual skills were required to switch to the use of machinery, included the production of chemicals and iron production, the widespread use of steam power and water power, the development of machine tools and the increase in mechanized factory systems. The first industrial revolution originated in England and then developed in Britain, North America and the Indian Subcontinent. In addition, the Industry 1.0 period started with the development and rise of trade, and continued with an improvement (Uslu, 2022, 52).

1.2. Industry 2.0

Industry 2.0, the second of the industrial revolutions, increased the division of labor and specialization with the use of electrical energy in production, thus making the transition to Industry 2.0 easier and faster. Henry Ford comes to mind when Industry 2.0 is mentioned. Ford started to use the newly found energy type electricity in production and started mass production and gained an important place in the Industry 2.0 period (Aksoy, 2017, 37).

Industry 2.0, which exists with the contribution of Fordism and Taylorism, is a period in which production with steel emerged first, and there were internal explosion engines, radio, telegraph and internal explosion engines (Şekkeli and Bakan, 2017, 19).

1.3. Industry 3.0

With Industry 3.0, machines no longer work with steam or electric power, but with computers. With the development of technology and the spread of software-supported production, the production has switched to automation system. Countries such as Japan, South Korea and China showed rapid development by coming to the fore in the Industry 3.0 period (Gökten, 2018, 882).

In the Industry 3.0 period, with the development of semiconductors, microprocessors, transistors, computers and the internet, which are also in the electronics class, progress and communication gained a new momentum (Tunçel et al., 2017, 155).

1.4. Industry 4.0

With Industry 4.0, the industrial revolutions in the past broke new ground and continue to develop and change today. The Industry 4.0 process is a period in which production and consumption completely change, the demands and needs of the customer come to the fore and production systems are determined accordingly. Some technologies have come to the fore in Industry 4.0. These;

Table 1. Industry 4.0 Technologies (Çirkin ve Özdağoğlu, 2021, 1538)

Endüstri 4.0`ın Temel Teknolojileri ve Uzantıları	**Açıklama**
Additive Manufacturing	The additive manufacturing system, also known as three-dimensional printing, is a system that can produce even complex products layer by layer in a short time by obtaining the part layer from the data of three-dimensional digital models, in contrast to traditional production systems such as milling and turning.
Augmented Reality	In addition to cooperating with individuals, autonomous robots not only contribute to flexibility, high quality and increased productivity in production, but also create a safe environment by performing dangerous and health-threatening jobs for the workforce.
Autonomous Robots	In addition to cooperating with individuals, autonomous robots not only contribute to flexibility, high quality and increased productivity in production, but also create a safe environment by performing dangerous and health-threatening jobs for the workforce.
Big Data and Analytics	It contributes to the storage, analysis and interpretation of high data rate, thus contributing to the determination of consumption habits by removing the profile of the customer, and it provides a benefit that will bring companies competing in today's globalizing world to the fore.
Cloud Computing	It is the provision of services related to computing through the internet, with high-speed, creative and flexible resources at an economical scale.
Cyber Physical Systems and Cyber Security	It refers to the network created by objects and systems through the internet, and the virtual environment created by simulation of objects and behaviors existing in the real world on the computer.
Horizontal and Vertical Integration	It simplifies production, increases resource efficiency and optimizes the global supply chain by cooperating with the internal and external environmental elements and tasks of the enterprise.
Internet of Things	It is the technology that enables all objects to reach the internet and interact and communicate with other devices.
Simulation	It is the creation of highly efficient and flexible production systems by imitating any system or process in real life in the same way on the computer and thus solving the problems at the same time by understanding beforehand.

2. CONCEPT OF HEALTH

Before explaining 4.0 in health management and technological applications used in the field of health, it is useful to define the concept of health.

In the past and traditional understanding, the concept of health has been perceived as the conditions in which a person has no disease and any disability, and has been defined within this framework. However, it should not be forgotten that illness and disability is an element that differs according to society and culture (Öztürk and Kıraç, 2019, 382)

Today, the concept of health is generally defined as follows: In daily life, it is the main right that the person should be careful about, not individually, but with more wishes, but which the relevant doctor can convey if a health-related treatment or opinion is to be declared, and the person is uncertain (Baloğlu, 2021, 50).

3. HEALTH 4.0

In this section, the Health 4.0 revolution, which emerged with the effect of Industry 4.0, and the health revolutions that occurred in previous periods related to health will be discussed. As in industrial revolutions, there are periodic developments in the field of health. These are Health 1.0, Health 2.0, Health 3.0 and Health 4.0. To summarize health trends briefly;

Table 2. Trends of Health (Karboub, vd., 2019, 2)

	Aim	Focus	Used Technology
Health 1.0	Increasing productivity and reducing paperwork	Automation	Computers and administrative software tools
Health 2.0	Improving data sharing and productivity	Connectivity – Network of hospitals/organizations	Cloud Computing
Health 3.0	Developing and equipping hospitals, providing hospital-based services	Communication with patients	Big data, wearables, optimization systems
Health 4.0	Value-centric service, real-time monitoring and monitoring	Prediction and diagnosis with artificial intelligence support	IoT, artificial intelligence, data analytics

Health 1.0: Health care is a stage where more doctors are centrally located. In Health 1.0, health care coincides with the first stage of technology. Patient records were made manually and services were provided with simple tools.

Health 2.0: The provision of health services has begun to be created in electronic environment with the method of simple networks. The registration procedures of the patients were also recorded with this system. Recording in the electronic environment has become a method preferred by healthcare professionals in order to communicate more healthily with patients.

Health 3.0: It has been a period when computers and digitalization became more concentrated and used. Obtaining data with the help of technology by collecting information is one of the main purposes. Genetic information has been used and wearable devices have developed. It is a stage in which sick people give information to other people through social media. This is called "Digital Healing" (Yalman and Filiz, 2022, 55-56).

Health 4.0 is defined as "a strategic concept for the healthcare field derived from the Industry 4.0 concept". The term is often used synonymously with digital health, m-health, e-health, and smart health. Behind this concept is the goal of virtualization in healthcare and personalization for patients, professionals and other stakeholders and the overall improvement of the technology and healthcare industry. In short, Health 4.0 can be defined as the phenomenon of improving health care and improving the connection between health care stakeholders using technology. As the main stakeholder of the digitally connected health system, the development of Health 4.0 technology, primarily meeting patient needs and improving the service received by patients, is at the center of this technology. To achieve this, the patient should receive the best possible and timely medical care when he needs it. This demand has led to the struggle for personalization of health with completely personalized services that offer the most benefit to patients (Bause et al., 2019, 888-889).

Health 4.0 provides a structural, behavioral and cultural transformation of health services by bringing virtuality and digitalization in the design and delivery of health services. The literature has understood Health 4.0 as the application of "Industry 4.0" principles to health care. More specifically, Health 4.0 requires "…a tactical deployment and management model for healthcare inspired by Industry 4.0". It aims to smarten the functioning of healthcare organizations by recontextualizing the delivery of healthcare services in the cyber-physical environment. Making this progress requires leveraging the potential of modern technologies such as artificial intelligence, machine learning and big data analytics (Ciasullo, 2022, 1).

3.1. Health 4.0 Technology Applications

The scope of Health 4.0 is quite broad. However, common Industry 4.0 applications used in Health 4.0 are listed as follows:

3.1.1. Use of Artificial Intelligence in Healthcare

Artificial intelligence can be defined as the imitation of human intelligence by "intelligent" machines that can make decisions autonomously and perform many different tasks that normally require humans. It is widely used in many fields for data structuring, feature extraction, classification and prediction. State-of-the-art technology offers different use cases in healthcare. Artificial intelligence can be used in the field of health for the following purposes:

- Monitoring the patient and providing accurate early warning for critical diseases such as cardiovascular diseases,

- Real-time decision making and assistance,
- Maximizing positive/negative predictive values,
- To accelerate obtaining primary diagnoses according to their urgency (Karboub et al., 2019, 3).

In addition, artificial intelligence is to help people stay healthy. Thus, they do not need a doctor or this need will decrease to a minimum after a while. The second application area is its use for both early diagnosis and diagnosis. With IBM's Watson for Heath application, it is very easy to access health data. Another application is treatment. It contributes to the detection and treatment of people with chronic diseases. It also contributes to research, especially helping the discovery of drugs. Artificial intelligence is used by doctors to decide which treatments they should apply. Another important artificial intelligence application is elderly care. It can perform elderly care in a way that reduces the use of hospitals and nursing homes. In addition, medical students can benefit from artificial intelligence in education (Büyükgöze and Dereli, 2019, 2-3).

3.1.2. Use of Cloud Computing in Healthcare

Cloud computing is a horizontal innovation consisting of a three-tier eHealth architecture designed to process data from ingestion to the cloud.

Medical Device Layer: This layer is where data is collected using different IoT. Strengthens the health 4.0 capacity to monitor patients in real time. This layer offers the advantage of being low cost and error free. Therefore, it generates sensitive and large amounts of data that must be handled with care.

Fog Layer: Equipped with high technology connected with different types of sensors. This subsection of sensor groups helps to process the incoming data in a very short time. After the data is processed, it is sent to the Cloud Tier for further analysis.

Cloud Layer: In this last layer, the cloud equipped with different high-performance computers can perform different highly specific tasks. The received data is also analyzed, stored and made available for further access by patients and authorized hospital staff. This layer allows both dynamic decision making and patient historical data (Karboub et al., 2019, 2-3).

3.1.3. Use of Blockchain in Healthcare

Healthcare always requires the collection, storage and use of sensitive data and classified information. They also require reliable operations and policies and adequate knowledge to ensure control and compliance. In addition, as healthcare systems expand to include multiple institutions or organizations along the value chain, reliable and secure methods of establishing contracts and agreements are required. Blockchain is one of the important and effective technologies for providing these services. With blockchain, secure and unalterable records can be stored and used for verification and security. Non-repudiation and transparency also ensure reliable contracts and clear agreements on cooperation

rules and procedures. It can also provide mechanisms to ensure fairness in data sharing and protect patients' privacy (Al-Jaroodi et al., 2020, 211191).

3.1.4. Use of Internet of Things in Healthcare

Lack of knowledge about a health problem and corresponding appropriate management can aggravate conditions and result in high mortality rates. Successful application of IoT in disease management and health education are key issues. With IoT and 5G, all kinds of multimedia material related to disease education can be sent to patients' mobile terminals, increasing their knowledge about their condition while integrating pharmacological and non-pharmaceutical treatments. In addition, IoT facilitates the assessment and monitoring of diseases. For example, patients can habitually check their tests and surveys using their mobile phones, so doctors can regularly monitor their patients' condition. Alternatively, healthcare professionals, decision makers and service providers can apply IoT to evaluate conditions dynamically and how they interact with environmental or behavioral aspects (Monteiro et al., 2018, 270).

3.1.5. Use of Big Data Analytics in Healthcare

A large amount of data accumulates in health systems over time. These become inputs for decision making and future planning practices. Big data analytics offers advanced mechanisms to discover health trends, correlations, and insights from this data. This helps improve healthcare, systems and treatment procedures; it reduces health costs, improves the quality of health services and facilitates decision-making for public health, and provides information to develop personalized treatments for individuals (Al-Jaroodi et al., 2020, 211191).

3.1.6. Use of Medical Cyber-Physical Systems (Medical CPS)

Medical CPS is used to facilitate beneficial interactions between the cyber world (eg software and control signals) and the physical world (eg equipment and patients) by providing ongoing health monitoring and treatment services. Medical CPS uses built-in feedback controls to accurately monitor and react to specific conditions. Examples of medical CPS are implantable medical devices (IMDs), such as deep brain simulators used to treat epilepsy, pacemakers used to regulate heart rate, and bio-instruments used to deal with biosignals (Al-Jaroodi). et al., 2020, 211191).

3.1.7. Machine Learning in Healthcare

Machine learning in health services is applied to provide high quality health services to patients in order to save both work and time to predict, diagnose and determine complications after the disease (Veranyurt et al., 2020, 278).

In addition, while obtaining medical data with machine learning, it is also possible to analyze and reach results quickly. As a result, rapid decision making, increased efficiency and clinical trials are being developed. While costs are reduced with machine learning in health, personalized treatments can be

determined and patient appointment planning is facilitated. Applications made with machine learning in the field of health are as follows:

- Identification of the disease and diagnosis of the disease,
- Personalized treatment, behavioral modification,
- Pharmaceutical invention and production
- Clinical research
- Radiotherapy and Radiology
- Smart Electronic Health Records
- Forecasting the epidemic (Kamer and Sancar, 2022, 18-19).

4. SOCIETY 5.0 AND ITS INTEGRATION IN HEALTH

Today, the period following Industry 4.0 has begun to be called and defined as Society 5.0. In addition, Industry 4.0 has affected the technological developments in the field of health, and Society 5.0 has started to direct the technological developments in the field of health, and it is foreseen that this orientation will also exist in the future. First of all, it is useful to explain Society 5.0.

Industry 4.0 was pioneered by Germany, while Society 5.0 was pioneered by the Japanese prime minister, who attended the CeeBIT Informatics Fair in 2017. He initiated Society 5.0 in Tokyo by defining Society 5.0 as technology should be understood as a help, not a threat to societies. The main purpose of Society 5.0 is to integrate technological developments and changes with society. In this way, technology will live in coordination with society (Saracel and Aksoy, 2019, 29).

In addition, Society 5.0 will help people develop a global perspective quickly, by changing the structures of institutions, organizations, professions, and blending them with technological developments. The individual, who will benefit more from machines in the coming years, will become more machine-dependent than before and will increase the expectation of a high quality life standard in people over time (Karoğlu et al., 2020, 148).

In addition to these, it is useful to refer to the United Nations' sustainable development goals in order to see the effects of Society 5.0 on health practices more clearly. According to Figure 2., the UN's sustainable development goals are as follows:

Health and quality life, which is the third of the 17 goals of sustainable development of the United Nations in Figure 2., includes health practices in Society 5.0. These are in health;

- Wearable health applications,

- Mobile health applications,

- Artificial intelligence applications. Thus, people will be able to manage their personal health (Büyükgöze and Dereli, 2020, 2-3).

Figure 2. Sustainable Development Goals **(**https://www.un.org/development/desa/disabilities/about-us/sustainable-development-goals-sdgs-and-disability.html Retrieved From: 15.11.2022)

5. CONCLUSION

Technological developments continue to exist and increase in the field of health. In this case, the important point is that health institutions should follow the technological changes and developments in both Industry 4.0 and Society 5.0. Today, when patients want to receive health services, they choose and will continue to choose health institutions that are technologically competent.

In addition to all these; health institutions must follow the technological developments and must not lag behind these developments. Thus, they will be able to keep up with the necessary competitive conditions. They will also provide a good health service with the application of technological developments.

Apart from these, new inventions will be made thanks to health-related technologies, and diseases and epidemics will be prevented. As a result, technologies applied in health are becoming increasingly important. These developments, which are related to human life, will benefit humanity. In fact, it is predicted that people will self-medicate with health technologies in the future.

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