DIGITALIZATION IN HEALTHCARE, TECHNOLOGIES USED, AREAS OF APPLICATION AND BENEFITS

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Abstract: Digitalization is an important factor in improving healthcare. As digitalization progresses, new opportunities are emerging for patients, doctors, medical staff, hospitals, health insurance companies, medical technology manufacturers, pharmaceutical industry, and other actors. Regarding digitalization technologies, proven and new technologies such as hardware and software, their networking and data processing are combined here. Depending on the focus of digitalization, this can involve optimized and automated workflows, or digitalization can be an enabler for new business models. The benefits for stakeholders in the healthcare sector are 61% through productivity increases for service providers and 39% through a reduction in medical requirements[1].

Keywords: Digitalization, healthcare, digitalization techniques, areas of application, benefits of digitalization, Germany.

Introduction

A study on life satisfaction and future expectations found that health is the most important thing to people. 87 percent of respondents say that health is essential. This makes it by far the most important area in the lives of individuals and society[2]. Therefore, a functioning health system with effective and efficient care for the population is an important goal of many responsible nations[3]. In highly technological countries, a change in this regard is evident in terms of advancing digitalization. The new technological possibilities are creating new starting points and opportunities. This raises the question: Which digitalization technologies can be used in different areas of application in healthcare, and what benefits does digitalization bring?

Research methodology

The study in this publication is based on a literature review, with a particular focus on understanding digitalization technologies in general and identifying specific areas of application in the healthcare industry. The benefits for the various players are also presented.

Results

A promising milestone in digitization in global health promotion was the first international health conference in Ottawa in 1986. Here, the Ottawa

Charter was adopted, which calls for active action towards the goal of "health for all" of the World Health Organization (WHO) in its preamble[4]. An important finding here was that health should and must be created and lived by us humans ourselves in our everyday environment[4]. It is also pointed out that health promotion is based on "communication and networking" through coordinated cooperation, including the media[4]. Digitization is an important building block for improving health promotion because there are a multitude of possible applications and uses between active companies in the health industry, doctors, patients and all other actors in this context.

Today, digitalization basically describes two perspectives. Firstly, there is a purely technical view of how analog signals are converted and stored into machine-readable data and information, as well as data processing and transmission processes using control units, computers, software and more[5]. The second view of digitalization concerns the everyday way we, as individuals and society, deal with digitalization. So to speak, the effectiveness of the interaction with and by people, the corresponding technologies and the design and use of their applications[5]. The term digitalization is often also equated with the introduction of digital technologies and as a driver of digital transformation [1].

In digitalization, the focus is on the various operational application software, which in turn are referred to as the term's information system or communication systems [2]. The technical enablers of digitalization consist of:

- basic technology
- networking
- data and information with appropriate processing methods.

The basic technology usually consists of a three-layer model: hardware, usually called a computer, an operating system and application software. Hardware consists of physical parts that enable computing processes and data transfer, in principle. The operating system makes it possible to make the hardware usable and available for the specific execution of the software applications. In addition, the basic technology is supplemented with appropriate administration and monitoring services [3].

Networking is when independent computers are connected to one another via various communication paths. These can also interact with people and machines with the help of technical support [3]. Communication paths consist of physical network connections, such as network cards with corresponding software. The connection and communication components in and between the networks are switches and routers for the data transmission paths.

Data and information are understood in the broadest sense as a sequence of machine-processable characters (basic elements of data representation) that describe objects and object relationships in the real world through their characteristics and thus represent information [3]. Basically, a distinction is made between industrial process data, business data, text data, image and video data, and biomedical data, as well as structured and unstructured data [4]. To extract decision-relevant information from the data that provides knowledge about facts and processes, a data set must be evaluated for a specific purpose and often supplemented with additional, external data [3]. Data processing with the appropriate processing methods – more precisely, data analytics and data science – are the key technologies for digitalization. According to estimates by the International Data Corporation (IDC), the global data volume in the healthcare sector will increase fivefold by 2025[6].

In the following, current trending technologies are presented, including their technical functionality and use in the healthcare sector:

The aim of **data mining technology** is to identify connections, trends and patterns in large data sets. Regularities and hidden connections should also be discovered [5]. The analysis and data mining methods are usually based on powerful artificial intelligence algorithms and are assigned to these systems [5]. Data mining generally refers to the analysis of a large data set without assumptions or value judgments [3]. The advantage of data mining systems is that they are unbiased and hypothesis-free [3]. Data mining enables new, useful insights from digital health data. This data is obtained from applications such as electronic patient files, electronic prescriptions, electronic certificates of incapacity for work, electronic medication plans, emergency data in general, communication in the medical field, and insured person master data management[7].

Business Intelligence BI defines the totality of all tools and applications to support decisions and better understand the mechanisms of relevant chains of effects. BI sees itself as a conceptual bracket that bundles a multitude of different approaches to analyzing relevant data [5]. Business Intelligence is software provided to the user to analyze and support options for action. Highly complex processing mechanisms run in the background. are seen overall for sophisticated solution approaches in operational planning and control tasks [5]. Business Intelligence is often used in hospital systems (HIS) and concerns patient care in the inpatient sector. The main goal here is the collection, processing and provision of patient-related information as well as documentation and administrative tasks to be handled efficiently [6].Management needs key figures on the quality and quantity of services provided to control hospital operations. It is therefore necessary to combine selected data from the subsystems of a HIS in a data warehouse (DWH). This data set can be used to determine the indicators required for decisions within the framework of business intelligence [6].

Big data is the evaluation of large, complex data sets. Big data and analytics are often combined to form the term big data analytics [7]. Big data includes methods and technologies for the highly scalable integration, storage, and analysis of polystructured data. In the medical field, big data applications aim to increase diagnostic precision and shorten the time between primary diagnosis and therapy, as well as increase therapeutic accuracy. In the field of tumor diagnostics and tumor therapy, Big Data technology can perform gene sequencing for the purpose of genetic analysis in tumors within 24 hours and produce tissue comparison in a maximum of two days [8].

Artificial Intelligence AI aims to simulate human abilities on a computer. Computers should be able to absorb information like humans with their sensory organs (sight, hearing, smell, taste and touch/feel) and perceive its content like the human brain [5]. The possible uses of AI systems in healthcare are now very diverse, as AI can extract information from data that a human cannot grasp because it is too large, or the underlying patterns are too complex [9]. AI therefore has the potential to revolutionize diagnosis, as it can collect, correlate, and evaluate data at rapid speed. Diagnoses can be made more objectively, faster, and more precisely than before [9]. For example, AI-based diagnoses using image data can be found not only in tumor diagnostics, but also, for example, in the early detection of dementia in magnetic resonance imaging images and cardiology [9].

AI also promotes the development of robot systems, or so-called **robotics**. Human-like structures are often designed and realized here that replicate the "thinking and acting" of humans. In a robot in a human-like form (humanoid robots), several human senses are usually simulated using special electronics [5]. The various fields of application of robots in the healthcare industry can be clustered into robots that are used to rehabilitate patients [10], robots to support nursing staff, diagnostic robots and emotional robots [10], robots to support the care of elderly and dependent people at home are communication and interaction robots, mobility and handling aids and complex assistance robots [10], medical or surgical robots, these have been established for 20 years, for minimally invasive procedures, as fully autonomous assistance functions, execution of teleoperation controlled by the surgeon and semi-autonomous execution of functions such as aligning an instrument to a localized tumor [10] as well as robots for training, medical interventions for surgeons and assistants [10].

Another key technology is **machine learning**. This technology belongs to the grouping of "learning systems" and is intended to improve a person's ability to adapt to learning. People expand their knowledge through learning. This process is made possible using artificial, neural, or networks [5]. Machine learning is also used in connection with AI and/or robotics. An example of machine learning is its use in the diagnosis and treatment of bronchial asthma. Here, the diagnostic asthma instrument is perfected by analyzing coughing sounds [9].

An additional enabler is **cognitive computing,** which is used to solve problems in complex systems in terms of multi-layered dependencies and interactions. Cognitive Informatics (CI) is a transdisciplinary inquiry of computer science, information science, cognitive science, and intelligence science that investigates the internal information processing mechanisms and processes of the brain. Advances and engineering applications of CI have led to the emergence of cognitive computing and the development of Cognitive Computers (CCs) that reason and learn[8]. This development has contributed to the evolution of robotic Process Automation (RPA) is moving towards so-called Intelligent Process Automation (IPA). IPA combines RPA with the key technologies of digitalization mentioned above to give classic software robots more advanced (cognitive) capabilities. So to speak, making them even more intelligent [11].

The **Internet of Things (IoT**) is a popular trend and the term for the network of physical objects ("things") that are equipped with sensors, software and other technology to network them with other devices and systems via the Internet so that data can be exchanged between the objects[9]. Medical apps are created on this basis; they provide health tips, analyze heartbeats, show contraindications for taking medication, screen dermatological patients, take medical histories and sometimes calculate the dosage of medication [12]. Furthermore, applications can be contributed by different manufacturers and also by participants in the platforms themselves. All devices are networked largely independently of the manufacturer [13]. Medical devices are already highly networked today and not only enable the exchange of the medical data and information generated with them, but also, for example, automated error detection and maintenance from a distance. This means that in addition to the basic requirements, in particular those for high data quality, there are increasing requirements regarding interoperability (the ability of different systems to work together as seamlessly as possible) and correspondingly high-performance data interfaces [13].

Blockchain is a decentralized database for the digital organization of property rights. Technically speaking, a blockchain is a database that is distributed as a copy across many computers [14]. A major hurdle regarding global healthcare systems is enabling the exchange of medical data between multiple actors for different purposes while still ensuring data integrity and the protection of patient data [14]. Blockchain technology, which is based on confidentiality, authenticity and integrity, would be an immense enabler here. An interesting project in this regard is Blood Chain, which makes it possible to track blood donations using new technologies such as QR codes or blockchain [14]. Other concepts include reducing manipulation of narcotic prescriptions, faster and more secure transmission of declarations of incapacity for work, and data protection for patient consents[8]. Blockchain is still very early in its life cycle for the healthcare sector, but it already has the potential to standardize secure data exchange in a bureaucratic manner [14].

Augmented Reality (AR) or, also called Virtual Reality (VR), depends on the environment in which the effect of virtual reality is created. AR is a computer-generated extension of perceptible reality, whereby additional information, such as text, images or virtual objects, is displayed in the user's field of vision. One area of application for AR glasses is nursing. This means that care staff can read all the information and instructions on a pair of glasses and have their hands free to work. The aim of AR here is to increase the quality of care and relieve the burden on nursing staff [15]. VR can provide hands-on training, such as activities that are common in a modern emergency department, and allows students to gain practical experience of life-saving interventions in medical training [16].

Industry 4.0 is also a forward-looking concept. Cyberphysical systems (CPS) form the technical basis of Industry 4.0. All objects can exchange messages with each other via Internet-like networks (Internet of Things, IoT). Cyberphysical systems have become a central component in product development and Industry 4.0 [17]. All production facilities for the manufacture of medical or pharmaceutical products are candidates for Industry 4.0. Every medical product, system, and pharmaceutical product that is produced industrially and used in the healthcare sector already has its first points of contact with cyber in the production chain, from development to maintenance and disposal.

Additive manufacturing/3D printing technology are used to produce three-dimensional workpieces.3D (dimensional) printing technology opens up the possibility of constructing complex shapes. 3D models are useful in medicine to obtain precise knowledge of the anatomical characteristics of an individual patient with the purpose of preparing complex interventions. The production of a model (e.g. heart, hip, vessels) is based on magnetic resonance imaging (MRI) data and computed tomography (CT) data, which are converted into a 3D model using special software and produced with a 3D printer. In this way, tailor-made, patient-specific heart valves, jaws, hip implants, etc. can now be produced [8].

Overall, the possible applications offered by trending technologies in connection with digitalization are very diverse, fascinating and complex.

Conclusion

All key players, i.e. the participants and regulators of the healthcare market, divided into healthcare facilities, doctors, patients, health insurance companies, manufacturers and retailers, as well as politicians and the executive [18], have organizational processes that offer typical digitalization potential.

The digitalization potential in healthcare is currently still divided into the following categories [19]:

– Online interactions, e.g. through teleconsultation or remote monitoring of chronically ill patients. These solutions primarily reduce the time required by patients and doctors

– Switching to paperless data processing, e.g. through electronic patient records and electronic prescriptions

– Workflows/automation, e.g. through mobile networking of nursing staff or barcode-based administration of medication

– Decision support through data transparency, e.g. through the use of software to avoid duplicate examinations of patients

– Patient self-care, e.g. through health apps or digital diagnostic tools

– Patient self-service, such as online portals for making appointments

The fundamental aim is to improve patient care. To this end, laws regulate secure digital communication and applications in the healthcare sector[10].

Another key aspect is the evaluation of the benefits of digitalization. The benefits are measured differently depending on the discipline and stakeholder. Lawyers ask about the fair benefit, doctors about the medical benefit, and economists about the economic benefit [19].

Benefits in the context of the actors in the healthcare industry are classified as personal, medical, qualitative, health economic, statistical, gerontological, economic, organizational, technical, procedural and legal benefits [19].

Digitalization in the German healthcare system holds a 42-billion-euro opportunity – per year. This corresponds to around 12% of the total annual health and care costs of 343 billion euros at the last count[1].

A switch from “paper to digital” as a potential for digitalization is usually the first step. However, there are countless digitalization opportunities and innovations in all interactions, from “person to person” to “person to machine”, from “machine to machine”, and in this special area, “person to machine to patient”[11]. For this purpose, the creation of a digital health strategy is recommended. This is an overarching plan with measures on how new digital health components are provided or how existing components are converted or expanded[12]. Ultimately, one also speaks of a digital health outcome. The digital health outcome is the desired change in the health system or health services using digital health interventions[12].

Notes

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