Current Studies in Healthcare and Technology

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ISRES Publishing

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This book was typeset in 10/12 pt. Times New Roman, Italic, Bold and Bold Italic.

Current Studies in Healthcare and Technology

Published by ISRES Publishing, International Society for Research in Education and Science (ISRES).

Includes bibliographical references and index.

ISBN

978-625-6959-17-0

Date of Issue

November, 2023

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Address

Istanbul C. Cengaver S. No 2 Karatay/Konya/TÜRKİYE

www.isres.org

PREFACE

Technology is radically changing our actions and habits in every aspect of life. Health and technology form one of the most exciting alliances of humanity's evolutionary journey. The meeting of these two fields profoundly affects every aspect of human life and reshapes the service provided by healthcare disciplines. Especially the fact that the development process in information technologies is at a leap point and the internet has become more accessible to everyone, carries R&D and service activities in the field of health to a new dimension.

In this book, written by academics with significant field knowledge in their field, we will explore the challenges and opportunities encountered in the use of technology in healthcare services. In the book, we cover issues such as accessibility of healthcare services in the context of technology, reflection of new approaches to practice, and artificial intelligence support. Additionally, we discuss ethical issues and various risks.

When the authorship of the work is examined, it can be easily seen that this book was written with a multidisciplinary approach. We believe that the same understanding will be effective in developing services and products in health care. The book you have in your hand is a product of this understanding. We would like to thank all our contributing authors and hope that it will be useful to all readers.

November 2023

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IN THIS BOOK

In Chapter 1, nursing is a practical profession in which critical thinking and psychomotor skills are used together. It is possible to have qualified nurses in the field of health only through adequate and continuous nursing education. Studies show that the classical educational model is not sufficient for the young generation of students. The fact that this situation has been recognized by both students and educators has revealed the necessity of updating theoretical and clinical educational methods. Today, the development of technology and constant self-updating of the information network are also reflected in educational systems. The educational curricula of the young generation, who are growing in the presence of technological infrastructure and separated from other generations in terms of educational and learning needs due to the modern age, must be updated according to their areas of education and their characteristics. On the other hand, alternative educational models are also needed due to difficulties encountered in clinical applications. In this chapter, it was aimed to examine the advantages and disadvantages of the current educational models used in nursing education in clinical applications along with the literature examples.

In Chapter 2, older population who may experience many physiological and psychological health problems has been increasing worldwide. Artificial intelligence systems collect and process large datasets to develop algorithms for chronic disease management and organization of care, optimize information delivery, and enable communication between caregivers and patients. For older adults to live an active, healthy, and independent life at home, assistive technologies utilize artificial intelligence to organize data flow from monitoring tools, including sensors and alarm systems, smart home gadgets, and telehealth. In this context, the importance of artificial intelligence applications in increasing the effectiveness of healthy aging programs in the digital age is increasing. This chapter aimed to integrate the knowledge and experience of nurses, which are an indispensable element of health service delivery, and artificial intelligence applications into the care process and to have knowledge and awareness about improving the health of older people and increasing their quality of life by providing maximum efficiency from these applications.

In Chapter 3, according to reports, the first mobile health applications were created in the 1960s to track the health of astronauts in space. Wireless devices that monitor an individual's heart rate while they are exercising were created in the years that followed, and with the advent of smartphones, mobile/web-based health applications began to gain popularity. Mobile/Web-based applications are widely used in health promotion, diagnosis, clinical treatment and care, home care and follow-up, patient and staff training, counseling, and coaching. Although there are many different types of use in health, mobile/web-based applications can be listed as telehealth applications, text messaging, smartphone applications, home care technologies, etc. Mobile/web-based applications have advantages as well as disadvantages.There are short-term results related to mobile/web-based health applications and there are no long-term outputs, and time is required for the formation of sufficient outputs that prove efficiency/effectiveness. In this chapter; It is aimed to examine the usage areas and purposes, types, advantages and disadvantages of mobile/web-based applications in the field of health with literature examples.

In Chapter 4, the health benefits of technology are many. However, its benefits in the field of health often cause ethical dilemmas for both health professionals and patients. Technology raises questions about the changing definitions of life and death issues with the developments in technology. Among the ethical dilemmas are which technologies should be used or stopped for which patient and who will decide. In this section, frequently encountered ethical problems related to technologies used in today's health field are examined.

In Chapter 5, the incorporation of medical imaging techniques into computer vision research has had a profound impact on the field of healthcare. The goal of medical imaging is to partition tissues and organs into segments, assisting doctors in understanding the body's internal structure. A variety of methods are employed to automate the segmentation of these organs. Particularly, deep learning methods have sparked a revolution in medical image segmentation. This chapter focuses on the role of deep learning in multi-organ segmentation within medical images, presenting the utilized deep learning method in this domain. Additionally, a study demonstrating multi-organ segmentation is also included.

In Chapter 6, the global impact of the COVID-19 pandemic, originating in China in 2019, has spurred urgent efforts in early and accurate diagnosis as well as effective treatment. Various diagnostic approaches, including antibody tests, RT-PCR, and Computed Tomography (CT), have been deployed to identify COVID-19 cases. Among these methods, CT scans have demonstrated heightened accuracy by revealing distinct radiographic patterns indicative of COVID-19. However, interpreting these images demands specialized radiologist expertise. In the contemporary medical landscape, artificial intelligence (AI), particularly deep learning, has emerged as a potent tool for disease diagnosis. Deep learning encompasses diverse architectures, notably Convolutional Neural Networks (CNNs), adept at image classification. CNNs excel in automatically identifying disease markers within medical images, owing to their robust feature extraction capabilities. Deep learning has extended to volumetric data, such as CT scans, resulting in 3D CNNs well-suited for processing such images. These models prove effective in diagnosing COVID-19 based on CT scans. Numerous studies have explored deep learning models for COVID-19 diagnosis via CT images. Researchers have combined various CNN architectures with innovative techniques to enhance accuracy. Hybrid models, merging CNNs and other architectures like Transformers, have demonstrated improved performance. These studies underscore AI's potential in aiding radiologists and medical practitioners to diagnose COVID-19 more efficiently and accurately.

In Chapter 7, in the developing world, the importance of health promotion is increasing day by day. Individuals need to have a healthy lifestyle in order to be healthy. The development of technology provides important contributions to our health. Technological products also offer opportunities to people to improve their health. The main purpose of public health is to prevent the occurrence of diseases. In this chapter, technological applications that can help improve health, based on Walker's Healthy Lifestyle Behaviors scale.

In Chapter 8, nursing is an applied health discipline, which has managed to renew itself with social, cultural, and technological changes from the past to the present. Surgical nursing focuses on the care of the patient in the perioperative process. In parallel with the progress in the surgical process and techniques, it is perhaps among the nursing fields that are most affected by technology. In addition to the safety risks of surgery, patient-related changes and complications can develop very rapidly in the perioperative period. The nurse's focus on the technological environment and applications can sometimes jeopardize patient safety, and technology, which is one of the risk factors related to patient safety in this challenging environment, can also be a tool to reduce this risk. In this part of our book, methods of using technology in surgical nursing will be examined under different headings.

In Chapter 9, with the increase in the world population and the development of technology, the need for health services has increased and the scope of the service provided has expanded. In order to meet this need, the use of developing technology in the field of health has become inevitable. Telehealth, which expresses the use of information technologies in the field of health, has become more widespread with the COVID-19 pandemic, although it has been used in the past. Today, telehealth services can be provided in a wide range from emergency response to chronic disease management, preventive services and rehabilitation. This chapter examines the concept of telehealth and its use in primary health care.

In Chapter 10, Today, emotion detection is used in many fields. Emotions of users are used to reach objective evaluations on digital platforms. It has been observed that advertising channels or movie reviewers are starting to use real-time emotion detection to detect users' emotions. Real-time emotion detection was performed in projects developed using deep learning (DL) and artificial intelligence (AI) algorithms. In this way, it is possible to follow the emotional changes of the users simultaneously while watching a video or movie. As a result of the accurate results of emotion detection used in similar studies, its use in the field of health was also evaluated. The evaluation system of many hospitals is based on patient opinions as well as statistical values. Studies have shown that these assessments do not adequately detect the patient's emotions. Emotion detection studies using multiple datasets can explain most very complex patient reviews that indicate only a few emotions. In particular, it is of great importance to detect the emotions of patients who cannot express their emotions and to prevent erroneous emotion detections. This study aimed to address the problem of perception of multiple emotions as a result of emotion detection studies in the field of health.

In Chapter 11, historically, Anatomy education has depended on techniques like human cadaveric dissection and textbook usage. As technology advances ever-rapidly, revolutionary ways of learning anatomy emerge. In addition, the consolidation of technology for teaching anatomy in medical courses was accelerated by the recent COVID-19 pandemic, which caused the need for social distance policies and the closure of laboratories and classrooms. Several technologies, techniques, and methodologies are utilized in anatomical education, but the ones explicitly receiving a lot of interest and traction are web-based mobile apps and augmented/virtual reality. Such applications are advantageous regarding student learning and the financial costs required for practical applications. With the widespread adoption of such new technologies by students, well-designed, multiplatform resources will become widespread, and it will be possible for them to access and learn necessary information in many fields more quickly, including anatomy, anywhere and anytime. This section assesses the characteristics of web-based and augmented/virtual reality applications used for learning anatomy, as the existing literature discusses.

In Chapter 12, physiology is a scientific field that focuses on maintaining the optimal functioning of an organism by regulating homeostasis. The body has a network of sensors that can detect even the slightest changes and intervene to maintain homeostasis. Modern technology enables detection at the microsensor level, further improving our ability to monitor and regulate the functioning of the body. Nanotechnology has played an important role in the diagnosis and treatment of cancer, a common disease of our age. Vaccine technology is also developing in parallel with current technological developments.Thanks to microchip discoveries and developments at the nano and micro level, studies are being carried out on cell and subcellular structures. Promising research is being conducted on stem cell therapy against common conditions such as neurological diseases, Alzheimer's disease and obesity. Advances in imaging system technologies have enabled us to better understand cellular interactions, and microsurgical techniques are also a result of current technological advances.

In Chapter 13, technology development has created opportunities for patients. With the support of technology added to modern diagnosis and treatment methods, these applications have become easier and more accessible. Childhood also affects a person's whole life. Digital technology is used to make the child healthier. With applications such as telehealth, children can be controlled remotely without going to the doctor. Mobile phone applications are also used to improve the child's health. In this chapter, it is aimed to examine the usage digital technology in health care for children advantages and disadvantages of applications with literature examples.

In Chapter 14, the integration of health and technology has provided effective and rapid solutions in diagnosis and treatment, as well as convenience in service delivery and high-quality outcomes. Technology has advanced in all areas. When we examine examples of technology usage in healthcare research, we encounter various methods such as wearable technology, artificial intelligence, and the Internet of Things for devices. The utilization of technology in health research paves the way for innovation efforts. Ensuring the applicability of new ideas and technological advancements to the industry is essential. The concepts of Intellectual Property Rights, Utility Model, and Innovative Product need to be defined to describe the generated ideas. In this section, innovation, current technological studies, and the patent process have been covered that based on a broad foundation in the field of health.

In Chapter 15, health technology enables early diagnosis, minimally invasive treatment, reducing the consumption of hospitals, reducing healthcare costs and improving the quality of life. Whatever the reason, it is not possible to prevent scientific and technological developments. The developments in health technology in the 21st century is a period in which many changes are experienced. These changes have greatly benefited public health by making life easier in many areas. In addition, many new problems arise, such as artificial intelligence overshadowing human intelligence, smart devices destroying the respect for their hands, and the medical profession becoming more passive. In addition, examinations of what will be the limit of the use of technological developments in human equipment, what kind of access to hospitals will be in the future, and how safe new technologies are are increasingly coming to mind. You need to make an effort to foresee these future situations.

In Chapter 16, the use of three-dimensional (3D) printing models in neurosurgery has become increasingly widespread in recent years for surgical training, pre-surgical planning and specialist training. In spinal surgery, which is anatomically variable and a challenging area in practice, it is important that surgeons adapt to the anatomy of the individual patient. 3D models allow visualization of complex pathologies, and the visualized anatomical structures are personal. The ability to create patient-specific implants leads to better adaptation of the implants placed, which increases long-term positive functional results. Although 3D printing methods have increased in research related to clinical applications, the need for quite specialized equipment and trained personnel has prevented their widespread use in clinical practices.

In Chapter 17, you will find the developments that technology has brought about in the fields of physiotherapy, occupational therapy and rehabilitation as in all areas of life. Technology is used by physiotherapists, occupational therapists and health professionals working in the field of rehabilitation in many different ways, especially Virtual Reality, Robotic Rehabilitation, Telerehabilitation, Wearable Technologies and Mobile Applications. We have tried to provide you, our esteemed readers and health professionals, with a resource that we think will be useful for the use of technology in the field of rehabilitation in the light of current literature. We hope to keep up with this rapidly developing and changing power every day.

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CHAPTER 1

Current Approaches in Clinical Practice in Nursing Education

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Current Approaches in Clinical Practice in Nursing Education

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Introduction

Today's age of rapidly advancing new technologies has led to different types of professions and changes in production and consumption resources. Socially, individuals' perspectives on life and expectations are also changing, leading to intergenerational differences (Bell, 2013; Kuyucu, 2017). Nursing candidates preparing for working life today and currently employed nurses are referred to as X, Y, and Z young generations (Isik et al., 2018; Karasu et al., 2017).Accordingly, some nurses from the X generation have retired, while some others are experienced nurses or educators working in clinical settings. Nursing academics are also training Y and Z generation nursing candidates. In this context, especially considering the Y and Z generations, who are closely intertwined with technology, nursing education should make use of technology by benefiting from simulation training and haptic systems and should improve in line with the characteristics of our modern era by using technological systems in work environments (Bell, 2013).

Nursing education continues throughout life, not only in formal education processes where theoretical and practical education is provided in coordination (Flott & Linden, 2016; Senyuva, 2013b). Based on evidence-based practices, nursing students are expected to graduate by using the necessary knowledge and skills in order to provide safe and quality treatment and care, They are also expected to develop critical thinking skills in order to give fast and most accurate reflexive responses in various health situations (Flott & Linden, 2016). However, despite the fact that nursing profession can be executed with strong knowledge and skills, several studies have found that nursing graduates are unprepared for professional life due to their lack of critical thinking and leadership skills (Durmus Iskender & Karadag, 2015; Flott & Linden, 2016).

To train more prepared and confident nursing candidates for professional life, we should be aware of the problems encountered during clinical education, an indispensable part of nursing education, and prevent their negative effects on clinical learning process (Elcigil & Sarı, 2011; Moscaritolo, 2009). Nursing graduates without proper competence and sufficiency leave clinical fields after a few years due to stress and burnout, in a way bringing the global nursing shortage along with them (Holdren et al., 2015).

Study Purpose and Problem

In addition to theoretical education, the application of current approaches in clinical education is very important for developing positive attitudes and behaviors in nursing students/nurses. When organizing, planning, and creating the content of nursing education, it is necessary to update both theoretical and clinical education models according to evolving and changing human profile and current conditions. For this purpose, this study examines the examples of current approaches in clinical education such as Simulation, Standardized Patient Model, Web-Based Education and Training, Distance Education, E-Learning and M-Learning, Video-Supported Education, Educational Games, Peer Coaching, Reflection, and Concept Mapping Model.

Simulation in Nursing Education

Increased number of nursing students, several limitations in nursing education such as inadequate number and quality of educators/clinical settings, and the growing awareness of patients about safety concerns have restricted opportunities for nursing students to perform their medical skills, communicate with physicians, work with multidisciplinary teams, and use critical thinking skills (Richardson & Claman, 2014). Along with many other obstacles, this situation has made it increasingly difficult to provide clinical experience to students, prompting educators to consider and use alternative methods such as simulation. The National Council of State Boards of Nursing suggests that simulation includes screen-based/computer-based simulation, virtual patients, partial task trainers, human patient simulators, and standardized patients (Mason Barber & Schuessler, 2018).

Simulation training provides students with experiential learning opportunities, increases their confidence, develops their clinical decision-making skills, and improves the quality of care. In this type of education, students can apply care practices in a safe environment where they can develop technical skills, decision-making, assessment, teamwork, and management skills without fear of misunderstanding the current situation or fear of failure (Goris et al., 2014). However, there are disadvantages such as the development of anxiety in students using this new method, the increased time and workload required for simulation education, the cost of providing a suitable laboratory environment for health education institutions, and the need for regular maintenance and inspection of simulation models (Midik & Kartal, 2010; Sanford, 2010). The advantages and disadvantages of simulators can vary depending on the complexity and technological features of the simulators used. Some low, medium, and high-spec simulators commonly used in health education are shown in Table 1.

Table 1
Simulators Used in Health Education

Low spec simulators	Partial task trainers Static mannequins
Medium spec simulators	Complex partial task trainers Computer-based simulations Virtual reality
High spec simulators	Patient simulators Standardized patients

Source: (Datta et al., 2012; Durmaz Edeer & Sarıkaya, 2015; Krishnan et al., 2017; Midik & Kartal, 2010; Sezer & Orgun, 2017)

Khalaila (2014) supported the information presented above, stating that the use of simulation as a learning strategy is useful and effective for nursing students before and during their first clinical practice. However, the author has emphasized that students' anxiety levels are high during their first clinical practice, therefore there is a need for a simulation program to be designed to reduce anxiety levels in nursing students (Khalaila, 2014). Similarly, Eyikara and Baykara (2018) reported that first-year nursing students who received simulation training had better vital sign learning skills and higher success rates, and suggested that simulation has a positive effect on nursing students' ability to measure vital signs (Eyikara & Gocmen Baykara, 2018). Another study found that satisfaction with education using highly realistic simulators was significantly lower compared to education using standardized patients, and this was attributed to the students' perception of reality (Luctkar-Flude et al., 2012).

In their literature review, Sari and Erdem (2017) examined several studies comparing high-fidelity simulators (HFS) with other educational methods (low and medium-fidelity simulation, traditional education) in terms of various characteristics, and reported that both methods resulted in increased knowledge scores, but in studies comparing anxiety levels, students who received HFS training had lower anxiety levels. They attributed this result to the opportunity for students to develop their skills in the most realistic environment before going to the clinic, without fear of harming the patient. The authors also found that HFS did not show a significant difference compared to standardized patient and virtual clinical simulation methods, and explained this by the fact that both standardized patient and virtual clinical simulation methods include a higher realistic medical environment (Sari & Erdem, 2017).

Standardized Patient Model

A standardized patient model with case study approach is a highly effective technique in obtaining desired outputs from clinical experiences. During the case review process, nursing students are able to observe the patient's health condition, identify unexpected changes that may occur over time, and allow for the individual-focused revision of nursing care plan through re-evaluating the patient in later stages. The scenarios presented in this practice create an environment for nursing students to measure their critical thinking skills, diagnostic reasoning, and clinical judgments, while providing them with suitable opportunities for demonstrating their clinical skills through direct observation, communication, and psychological assessments during the process of obtaining patient history, conducting physical examinations, and evaluating patient's psychological state

(Marion et al., 2018; Mason Barber & Schuessler, 2018).

Effective communication skills are essential for healthcare professionals within the healthcare system (Lin et al., 2013). Nurses, whose primary focus is on human beings, should evaluate individuals with a holistic approach throughout their interpersonal communication and interaction processes, and develop a foresight for their emotional and mental state. Therefore, it is important for nursing students to acquire these competencies (Jacobs & Van Jaarsveldt, 2016). Poor communication between patients and healthcare providers can lead to increased complaints and claims of mistreatment. The immediate feedback provided by the standardized patient model plays an important role for nursing students to develop interpersonal communication skills (Lin et al., 2013).

WEB-Based Education and Training

The inadequacy of traditional methods used in the education process and the desire to benefit from the developments in the field of communication and technology and to provide a quality education have revealed distance education models. By using tools such as video, graphics, and multimedia technology, web-based education and training methods provide the opportunity to deliver education to students outside of school (Akman & Guler, 2008; Bahar, 2015). Web-based education largely leaves the responsibility of meeting educational needs of individuals, who have diverse sociodemographic characteristics and disrupted educational processes due to geographical conditions, to themselves, and helps them develop decision-making and problem-solving skills (Senyuva, 2017). To ensure the quality of nursing education methods in web-based learning environments, both theoretical and practical education should be provided using a learner-centered approach, as the roles of students and teachers change (Boz-Yuksekdag, 2015).

Uluyol and Guyer (2014) reported a significant increase in critical thinking skills after nursing students participated in face-to-face classroom discussions using web-supported case study methods. They attributed this result to the discussion environment providing nursing students with multiple perspectives, the opportunity to benefit from each other's knowledge and experience, and the effectiveness of their desire to reflect their own thoughts (Uluyol & Guyer, 2014). Although web-based teaching models have benefits for both trainers and learners, they also have some limitations for both parties (Table 2).

Table 2

Benefits/limitations of web-based teaching models for both learners and trainers

	Benefits of Web Based Teaching Models
For learners	Providing a learning environment independent of time and place
	Allowing watching again the trainings that cannot be repeated very often due to crowded classes in applied trainings, whenever desired
	Reducing recall and learning time thanks to a learning environment that appeals to multiple senses
	Putting students in the center instead of trainers in education and training and designing the system in a way that students can perceive

For trainers	Providing the opportunity to reach many people with the advantages of multimedia Enabling students to track their coursework and studies outside of class Preventing trainers from not having enough time to evaluate student assignments, being unable to keep student activities, and not being able to make process-based evaluations Enabling all information to be updated quickly from a single center
	Limitations of Web-Based Teaching Models
For learners	Inability to create a sense of community among students Possible disappointment due to unmet student expectations Failure to consider the specific needs of students who take this education for the first time Inadequate academic, technical, and advisory support for students Feeling of social communication deficiency due to the lack of mutual communication process Requiring a certain level of technical knowledge and computer literacy Possible negative impact on students' critical thinking processes Long preparation processes
For trainers	High cost of the process Requiring a certain level of technical knowledge and computer literacy Having complex planning and organization process (requiring professionalism) Inadequate level of experience of teaching staff Institutional barriers disrupting the process due to financing, infrastructure, and technological problems

Source: (Bagriacik Altintas & Vural, 2018; Bahar, 2015; Barisone et al., 2019; Bilgic & Tuzun, 2015; Boz-Yuksekdag, 2015)

Distance Education

Distance education is a computer-based, online teaching method in which education-training interaction between educators and students is provided in cases where classroom education cannot be done due to the limitations of traditional methods. Distance education has emerged as an alternative due to problems encountered in traditional methods such as distance, insufficient capacity of educational institutions, and lack of teaching staff. Distance education enables a large number of students to receive education in a short period of time and at the same time, without physical barriers such as time and geographical distance, and to access any educational program at any center (Eygu & Karaman, 2013; Ozturk, 2015; Senyuva, 2013a). This method supports formal education in nursing education, contributes to lifelong learning, and provides equal opportunities for students. After graduation, distance education can also provide nurses with the opportunity to increase and develop their professional and individual qualifications within a flexible framework, as well as continuing their education while working (Ozturk, 2015; Usun, 2006). When designing distance education programs in nursing education, it is important to identify the target audience. Therefore, the content should be planned according to the answers given to the questions of "Do the students who will participate in distance education have theoretical knowledge and skills related to nursing profession? Are the students who will receive education in this field nurse candidates with no knowledge?" In addition, it should be determined which learning techniques students primarily use (such as listening, reading, writing, discussion) and how to convey the necessary theoretical knowledge and provide relevant feedback (Boz & Kurubacak, 2008). Considering the perceptions of nurse academics regarding distance education, those having distance education are more motivated and tended to make more independent decisions and search for the course content in more detail and comprehensively compared to those having traditional education (Mancuso, 2009).

Distance education is also applied in basic nursing education, as well as post-graduate education and certificate programs in developed countries such as Europe and the United States (Senyuva, 2013a). The first distance education in Turkey started with the "Associate Degree Program in Nursing" between the 1990-1991 academic years, and the web-based "Undergraduate Completion Program in Nursing" was opened in the 2009-2010 academic year. No student registrations have been accepted for the associate degree program since the 1998-1999 academic years, and the undergraduate completion program is still ongoing. In the 2011-2012 academic year, the Inonu University Institute of Health Sciences Surgical Diseases Nursing Distance Education Non-Thesis Master's Program was opened (Ataturk University Distance Education and Research Center, 2017; Boz-Yuksekdag, 2015; Kahyaoğlu Sut & Kucukkaya, 2016; Ozturk, 2015). In addition to its opportunities and advantages, distance education also has some limitations (Table 3).

Table 3

Advantages and limitations of distance education

Advantages of distance education (Boz & Kurubacak, 2008; Kahyaoğlu Sut & Kucukkaya, 2016)	**Limitations of distance education** (Kahyaoğlu Sut & Kucukkaya, 2016; Senyuva, 2013a)
Distance education is an economical option to reach information	To achieve nursing competency, theoretical education must be supported by practice, but cannot be carried out at the desired level in distance education
The use of audio and visual materials in distance education environment provides permanence (for example; 3D animations, video images, pictures, drawings, etc.)	There are difficulties in communication between students and educators
It enables schematic representation of theoretical knowledge of basic sciences (anatomy, physiology, pathology, biochemistry, etc.) and basic nursing courses	It reduces socialization
It benefits nursing candidates in increasing their theoretical knowledge and alleviating their fears and concerns before application	Problems encountered during learning cannot be resolved immediately
Interaction between students from different locations is important for them to evaluate themselves and to know that they are not alone	There are difficulties in teaching topics that require practical application

Graduate nurses can review their applications, update their professional knowledge and skills, be aware of innovations in the field, and find opportunities for education and self-improvement during irregular working hours	Having a large number of students has negative effects on learning

As a result, distance education is not a method that can be applied alone for nursing education, but rather it should be planned to support traditional education, especially in basic education, and to enable lifelong learning after graduation (Ozturk, 2015).

Electronic Learning (E-Learning) and Mobile Learning (M-Learning)

Electronic Learning (E-Learning) refers to the use of rapidly developing digital technologies such as social networks in education. The use of digital technologies is inevitable in nursing education to facilitate learning, reinforce knowledge, and make efficient use of time. E-Learning is included in nursing curricula in many countries, including Australia, Canada, Greece, Ireland, New Zealand, the UK, and the US (Button et al., 2014; Voutilainen et al., 2017).

Over the past 50 years, mobile technology and devices have entered many areas of life including education, business, and communication. The concept of Mobile Learning (M-Learning) has emerged with the integration of mobile technologies into the field of education (Adiguzel et al., 2014). M-Learning provides access to educational content without being tied to a specific location, facilitates communication with others, responds to individual needs of uses, and increases productivity (Ozdamar Keskin & Kilinç, 2015; Voutilainen et al., 2017). In addition to these advantages, M-Learning meets the unlimited demands of the new generation of students with its uninterrupted learning process (Sahin & Basak, 2017; Tekdal & Saygıner, 2016). M-Learning also refers to learning without a fixed location" and "learning with the advantages of mobile technology, mobile phones, and Personal Digital Assistants (PDAs). With the expansion of wireless internet networks, interest in E-Learning has shifted towards M-Learning (Ozdamar Keskin & Kilinc, 2015; Voutilainen et al., 2017).

Mobile devices are easy to carry, use, and access. Although not yet widespread in nursing education, mobile applications can be used in many areas, including medication information and dosage calculations, basic sciences such as anatomy and physiology, and the interpretation of laboratory findings, for nursing students who have online access anywhere. On the other hand, technology-supported M-Learning enables nursing students to be in different locations with paperless learning environments, practical and advanced virtual environments in situations where they are restricted (due to a low number of cases, insufficient clinical practice time, etc.), and contribute to the new generation of nursing education (Mackay et al., 2017; Sahin & Basak, 2017).

In summary, the effective use of the developing knowledge network by nursing students who are familiar with new generation technology and their willingness to do so require the integration of E-Learning and M-Learning techniques into nursing curricula. Educators should also organize educational programs according to the needs, interests, and abilities of the new generation nursing students (Sahin & Basak, 2017). Studies have shown that students' motivation, self-confidence, and satisfaction are high in education provided through E-Learning and M-Learning (Chung, 2013; Gagnon et al., 2013; Lee et al., 2016). Ozturk and Dinc (2014) compared traditional methods with E-Learning in urinary catheterization skills training and found that students who received practical training through E-Learning had higher evaluation scores (Ozturk & Dinc, 2014).

Video-Supported Teaching

To enhance the psychomotor skills of nursing students and increase their competency in care services and treatment process prior to clinical practices, traditional methods are currently used in conjunction with educational methods such as real clinical scenarios, role-playing, video demonstrations, simulated and standardized patients (Mete & Uysal, 2010). The use of scientific videos in skills training is considered a pedagogical method that combines theoretical knowledge and practice. Video-supported education has several advantages for students such as developing cognitive aspects, causal reasoning, critical thinking, and problem-solving. Therefore, visualizing information makes learning and remembering easier, which increases students' motivation and enjoyment of learning (Akin Korhan et al., 2016).

Although studies on the use of video-supported teaching in psychomotor skill education in nursing are limited, its usage is increasing day by day. Korhan et al. (2016) has shown nursing students several videos related to nursing practices before skill laboratory practice, whereby the students reported that having practices through videos and other visual course materials made learning and reinforcement of skills easier for them (Akin Korhan et al., 2016). Elcigil and Sari (2011) collected data using a "focus group interview method" to identify facilitating factors in clinical education for nursing students, and emphasized that having good relationships with team members in the clinical setting positively affected the students' learning, whereby they were more motivated and willing to learn when they felt like part of the team. The authors also highlighted that the students' communication with their supervisors greatly influenced their clinical performance (Elcigil & Sari, 2011).

Educational Game

Due to the increasing use of technological devices such as smartphones, tablets, and computers, especially among young people, students' expectations have started to change in educational environments (Koivisto et al., 2016). This situation has led educators to search for different approaches. As it becomes more challenging to attract students' attention and conduct effective education, educational games have been introduced as a teaching strategy since the beginning of the 20th century. Recently, educational games have also begun to be used in nursing education (Johnsen et al., 2018; Kinder & Kurz, 2018; Pront et al., 2018; Royse & Newton, 2007). The aim of playing games or providing nursing care is considered as a problem-solving process (Koivisto et al., 2016). Educational games such as video games, computer games, simulation games, 3D laboratory games, and other educational games that individuals can prepare according to various conditions can be integrated into traditional nursing education to make learning fun and increase motivation in nursing students (Blakely et al., 2009; Gallegos et al., 2017; McLafferty et al., 2010; Strickland & Kaylor, 2016). However, when creating educational games, it is necessary to establish fundamental rules and regulations, match theoretical knowledge with practical knowledge, and provide appropriate feedback (Gallegos et al., 2017). It should also be able to incorporate both competition and fun. If the requirements for creating educational games are met, nursing students can improve their knowledge and skills without the fear of making mistakes, feeling more comfortable (Johnston et al., 2013). Although the benefits of this method and its facilitation of learning are mentioned in the literature, the studies on this subject are quite inadequate (Gallegos et al., 2017).

As with any educational method, the educational game method also has its advantages and disadvantages (Blakely et al., 2009). Its advantages can be listed as reducing stress and anxiety, increasing motivation, teamwork, and interaction, as well as making learning fun and getting away from the monotony of traditional teaching methods. However, its disadvantages include competition during the game, which can increase stress and embarrassment or be perceived as threatening, the need for some games to require special preparation and cost, and making individual evaluation difficult (Blakely et al., 2009). According to research, students' feedback reveals both positive opinions and negative aspects and areas for improvement in educational games (Gallegos et al., 2017; Koivisto et al., 2016). Koivisto et al., (2016) aimed to teach postoperative care through a 3D simulation game for students taking surgical nursing courses and determined that nursing students who were used to play games daily or frequently were more successful in all care stages than those who did not play games at all. The authors also observed that even if the students played games alone, they worked in collaboration with other students during decision-making, thus developing teamwork and social relationship skills, which are also essential in clinical practice in nursing (Koivisto et al., 2016).

Although there are many educational games such as visual games, visual reality, and digital games, computer-based games are generally used in the field of nursing (Pront et al., 2018). Although it is not certain whether there is a definite benefit or harm in the results of the study, the literature generally mentions the positive effects of games on education. Therefore, it is important to design the lesson to be applied in order to achieve the positive effects of the game, taking into account several factors such as the age of the students, and to publish the results to guide other educators.

Peer Coaching

In parallel with recent changes in the field of education, nursing education has also changed and developed. However, due to various factors such as a greater emphasis on theoretical knowledge in nursing education, a shortage of teaching staff, a high number of students, and expectations of teaching staff to perform duties other than teaching, there are significant problems in using this theoretical knowledge in clinical practices. Therefore, nursing students need someone in the clinical setting who can share their experiences and provide guidance. A new approach called "peer coaching" has been proposed as a solution in response to this need (Ay, 2007; Waddell & Dunn, 2005).

Peer coaching, also known as discovery learning, aims to facilitate knowledge transfer and mutual development between individuals of similar ages and experiences (Broscious & Saunders, 2001; Yava & Sutcu Cicek, 2016). Although coaching and mentoring are often used interchangeably, they are distinct concepts in the literature. Coaching is considered one aspect of mentoring, and the key difference between coaching and mentoring is that coaching adopts an approach based on both skill training and theoretical knowledge (Sezer & Sahin, 2015). Certain components should be present to ensure the effectiveness of peer coaching. When these components are present, this method provides many benefits for both students and their coaches. These components include identifying the estimated transfer needs, teaching clinical application behavior through demonstration and instruction, creating opportunities for practice, providing non-judgmental feedback, and encouraging questioning and self-assessment (Waddell & Dunn, 2005). When providing feedback, the most important point is to provide positive feedback that reinforces correct practices and helps correct incorrect practices (Waddell

& Dunn, 2005; Yava & Sutcu Cicek, 2016). If peer coaching is applied correctly, it provides various advantages for both learners and their coaches (Table 4) (Bensfield et al., 2008; Broscious & Saunders, 2001; Yava & Sutcu Cicek, 2016).

Table 4
Advantages of Peer Coaching

	Advantages of Peer Coaching
For learners	Develops a sense of responsibility for nursing student roles,
	Decreases stress level while learning basic nursing skills,
	Develops organizational skills
	Develops interpersonal relationships
	Develops collaboration skills
	Allows to have an opportunity to observe positive role models,
	Increases professional power among nursing students,
	Increases self-confidence in nursing students,
	Its educational environment is not limited to only instructors and students,
	Allows students to feel more comfortable, safe and makes learning easier
For peer coaches	Increases self-confidence for clinical nursing roles,
	Develops leadership skills,
	Increases self-confidence regarding skill proficiency,
	Develops interpersonal skills,
	Develops critical thinking skills,
	Increases knowledge and experience of students by using various strategies for learning and teaching basic nursing skills,
	Develops perspectives on nurse educator roles

Reflection

Reflection is a detailed thinking process about a situation that a person has experienced, and it can be done in written form or through small group discussions. An individual can write about a situation that has affected them in a self-evaluative way. The reflection process consists of four steps: 1. returning to past experiences, 2. focusing on one's feelings, 3. re-evaluating the experience, and 4. Learning (Deliktas et al., 2016). By focusing on their own actions, thoughts and emotions and analyzing, questioning, and examining their individual values, beliefs and attitudes, individuals can have the opportunity to explore and discover themselves (Deliktas et al., 2016; Ferszt et al., 2017). Reflection practices that develop problem-solving skills also help nursing students to notice different experiences and problems they face during academic courses or clinical practices, recognize their strengths and weaknesses, and develop their ethical aspects (Deliktas et al., 2016). For example, in class, a week before a lesson, nursing students are asked to read a reflection about "a spouse taking care of a wife with Alzheimer's disease" and select a sentence that interests them. They can be asked some questions about the experience they chose, such as "What did you learn about yourself after reading this thought?" and "What did you learn about the impact of this disorder on the patient and/or her family?" The students are then divided into groups of 4-6 and asked to share the sentences they chose and the reasons behind their choices. Each group then shares a summary of their group discussion with the entire class. As a result, this activity offers them the opportunity to learn from their peers (Ferszt et al., 2017).

Concept Mapping Model

One of the main goals of nursing educators is to equip nursing students with skills that will enable them to continue learning independently even after completing formal education. In the rapidly changing and evolving age of information, concept mapping is one of teaching methods that can help nursing students access, organize, and distinguish important and unimportant information. Concept mapping uses flowcharts to organize basic concepts and make it easier to understand the relationships between them, promoting critical thinking, organizing knowledge, identifying relationships between concepts, and integrating theoretical and practical education (Yue et al., 2017). Concept mapping present a visual presentation of the relationships between key terms derived from the learned topic, which has a lasting effect on students' learning outcomes. In their semi-experimental study of 64 nursing students, Jaafarpour et al. (2016) found that concept mapping has a positive effect on students' learning outcomes and academic achievements (Jaafarpour et al., 2016).

Nursing profession gains its quality by integrating knowledge, skills, and critical thinking skills. Concept mapping is also an alternative and valuable method for developing critical thinking skills. Kaddoura et al. (2016) found that nursing group with concept mapping performed better in terms of critical thinking skills than those with traditional methods (Kaddoura et al., 2016). As a result, concept mapping is one of the effective teaching tools that positively contributes to the quality of nursing education (Kinchin, 2014).

Conclusion and Recommendations

Active learning methods and models are frequently used in nursing education today. These methods provide positive affective, cognitive, and psychomotor outcomes for nursing students. Additionally, nursing students may miss out on opportunities to learn and practice in real medical contexts due to safety and practical reasons. Therefore, it is highly important to involve nursing students in contexts where they can learn to communicate with patients and make judgments based on what they observe in the field, in addition to what they learn from textbooks. Especially considering the challenging social expectations for new graduate nurses, active learning programs can contribute to meeting their needs for nursing profession in practice. Therefore, educators and nursing students should be encouraged to use these methods. Furthermore, there is a need for further studies on these methods in both theoretical and clinical applications.

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Similarity Index
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To Cite This Chapter:
Aygin, D., Cengiz Acil, H., Celik Yilmaz, A., Yaman, O. & Gul, A. (2023). Current Approaches in Clinical Practice in Nursing Education. In S.N. Guner, Y. Uzun & I. Cetin (Eds.), *Current Studies in Healthcare and Technology* (pp. 1-18). ISRES Publishing.

CHAPTER 2

Digital Transformation in Improving Elderly Health with a Nursing Perspective: Artificial Intelligence Interventions

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Digital Transformation in Improving Elderly Health with a Nursing Perspective: Artificial Intelligence Interventions

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Introduction

The proportion of older adults worldwide has increased rapidly compared to the younger population due to declining fertility rates and increasing life expectancy (Chu et al., 2022). It is estimated that the population aged 65 and over worldwide will double (17%) from 8.5% by 2050. While the number of people aged 65 and older, regarded as Turkey's senior citizens, was 6 million 651 thousand 503 in 2016, it ascended by 24.0% over the previous five years to 8 million 245 thousand 124 in 2021. Older adults accounted for 8.5% of the total population in 2017; however, that number rose to 9.9% by 2022. According to population projections, the percentage of older people is expected to be 12.9% in 2030, 22.6% in 2060, and 25.6% in 2080 (Turkish Statistical Institute [TUIK], 2022). Longer life expectancy leads to exposure to more disease risk factors and causes an increase in the number of chronic diseases. As a result, older adults face problems that may affect their ability to independently perform daily activities or functional capacity. While the old-age dependency ratio in our country was 12.6% in 2017, this ratio increased to 14.5% in 2022 (Turkish Statistical Institute [TUIK], 2022). Moreover, it increases the burden of elderly individuals on health care services due to the increased frequency of hospitalizations, morbidity, and mortality rates. In recent years, one of the most important contributions in reducing this burden in the healthcare sector and elderly care services has been the developments in information and network technologies. Especially smart watches and smartphone tracking technologies stand out with their applications for healthy living. In addition to these mobile technologies, models have been developed to improve the quality of life of older people living alone in many subjects, including health and safety, thanks to smart sensors and patient monitoring systems, wearable devices, and smart homes supported by the concepts of the Internet of Things (Chen, 2020; Rubeis, 2020; Chu et al., 2022).

To achieve the goals of the United Nations Decade of Healthy Aging, countries need to meet the health needs of current and future elderly populations with innovative solutions (Chen, 2018; Chu et al., 2022). Artificial intelligence's (AI) rapid development and success have led to the reshaping of healthcare services for older people, similar to many other businesses and professions (Chen, 2020). The recent development of AI-enhanced methods to enhance and improve older people's health is due to the interaction between an aging population and rapid technological advancements. In considering this, research into the potential impact of AI-based technologies on the future has increasingly focused on the healthcare sector (Chen, 2020).

Equipped with functions that resemble human intelligence, including the ability to recognize, learn, reason, adapt, forecast, and make decisions, AI plays a current and important role in the care of older adults by monitoring their health status, complementing existing care services and reducing the burden of family caregivers (Rubeis, 2020). Artificial intelligence can act in virtual spaces based on software systems (for example, speech agents, and facial recognition systems) or in physical environments based on hardware (for example, robots). Using AI is a developing trend in technology encompassing a range of advanced computational techniques, primarily machine learning, and natural language processing. These techniques can be applied to healthcare datasets to increase the success of improving and predicting patients and healthcare outcomes, using them in clinical decision-making and care delivery (O'Connor et al., 2022). These innovations may increase the sustainability of the workforce in healthcare (for example, act as additional support to caregivers), address service inequality (for example, provide long-term care services for older people in remote areas with low availability and high demand), and increase productivity in the older population (Chu et al., 2022; O'Connor et al., 2022). For this reason, it is important to increase AI-based applications and develop new technologies, especially in elderly care, to increase the quality of life.

The Importance of Artificial Intelligence in Improving Elderly Health

Due to the biological changes accompanying aging, physical health problems that older adults may experience include hearing loss, decreased vision, joint and muscle pain, chronic diseases such as hypertension, diabetes, and cognitive disorders, including dementia. In addition, it is emphasized that AI techniques can help improve the patient and other health outcomes, as older adults are more likely to be frail and experience incontinence, falls, delirium, malnutrition, and pressure ulcers (Chu et al., 2022; O'Connor et al., 2022; Loveys et al., 2022). It has many physical and virtual world applications, such as predictive algorithms based on AI, clinical decision support systems, robotics, remote monitoring systems, mobile applications, wearable devices, virtual reality, and game technologies. AI systems collect and process large datasets to develop algorithms for chronic disease management and organization of care, optimize information delivery, and enable communication between caregivers and patients. For older adults to live an active, healthy, and independent life at home, assistive technologies utilize AI to organize data flow from monitoring tools, including sensors and alarm systems, smart home gadgets, and telehealth. Assistive robots for preserving mental and physical health, education, rehabilitation, and psychosocial support are among the human-computer interface technologies based on AI (Chen, 2018; Loveys et al., 2022). In this context, the importance of AI applications in increasing the effectiveness of healthy aging programs in the digital age is increasing.

Considering the studies, AI-based interventions significantly improve functional capacity, cognitive performance, depression, and nutritional status in older adults, facilitate the early identification of behavioral and psychological symptoms associated with geriatric syndromes, and improve quality of life by optimizing the care processes of older adults (Ronquillo et al., 2021; Chu et al., 2022; O'Connor et al., 2022; Loveys et al., 2022). In addition, the participation of elderly individuals in health services is supported through analysis based on the prediction of the prognosis and health risks of chronic diseases, individualization of care management, prevention of health risks based on behavioral analytics, collection and sharing of health data (O'Connor et al., 2022; Loveys et al., 2022). For this reason, AI has been increasingly used in recent years to support the care of older adults, mainly by providing a new opportunity for gerontology nursing practices (Chen, 2020). In this context, it is important to integrate the knowledge and experience of nurses, which are an indispensable element of health service delivery, and artificial intelligence applications into the care process, and to have knowledge and awareness about improving the health of older people and increasing their quality of life by providing maximum efficiency from these applications.

Artificial Intelligence-Based Health Monitoring Technologies

Numerous commercially available gadgets and systems, including those found in readily available smartphones, gather health data (including information on physical activity, diet, blood pressure, and heart rate monitoring) that may provide an overview of a senior's overall quality of life (Luo et al., 2018; Ho, 2020). Especially if artificial intelligence monitoring technologies are integrated into the electronic health records of older adults, therapeutic interactions can be made easier. AI-based technologies can help support older people with cognitive problems or dementia or patients with difficulties expressing their symptoms and health needs.

Artificial intelligence health monitoring technologies are based on monitoring data such as physical activities, nutritional information, blood pressure, and heart rate monitoring. However, it has gone beyond collecting and monitoring various indicators in recent years. Based on this data, it has become a system that makes predictions and decisions for applications. It does this with machine learning. According to Ho (2000) and Luo et al. (2018), machine learning is a part of AI that utilizes statistical methods to enable computer programs to predict the future and make decisions based on previous data. This allows programs to improve their tasks over time. Many data from longitudinal observation may be continuously collected and analyzed by these optimization algorithms, which can also recognize and classify trends, utilize predictive analytics to determine the risk level, and offer recommendations on behavior or care (Galambos et al., 2019). For instance, AI-enabled blood pressure and electrocardiogram monitors can aid in predicting several health issues (hypertension, atrial fibrillation, etc.) (Luo et al., 2018; Ho, 2020). Advanced AI health monitoring systems, such as computer vision analytics, may classify actions like standing or walking and how long it takes to get out of bed before constantly learning the expected movements or actions, such as ease and comfort for a particular older adult in each setting.

The sensors, which are installed in various places in the home of seniors and can monitor the total daily activity, the time spent away from home, the walking speed, and the position at home, can also help to record the indoor activity durations, types, and characteristics of the older adults (Ho, 2020). In addition, early intervention can also play a key role by identifying unusual movements and activities that may indicate a decline in the cognitive and functional capacity of older people by AI health monitoring systems (Galambos et al., 2019). These technologies offer detailed real-time information and automated alarms to support immediate proper care, potentially preventing an older adult's unexpected decline in health status or severe injury. This can delay costly institutional care and allow older people to continue care in their homes where they feel more comfortable and safer (Giger et al., 2015; Galambos et al., 2019). For instance, AI monitoring systems that continuously analyze input data may detect that it takes an older person progressively longer to regain their balance as they try to stand up or regain their balance. The automated analytical system can decide to take action based on a predetermined risk threshold by providing pre-warning messages or behavioral guidance to the older person and caregiver after calculating the health decline using the collected data (Giger et al., 2015; Galambos et al., 2019). Health assessments consider how the relevant markers can change over time under recognizable settings tracked by monitoring devices rather than just a set of markers at a specific time. In this situation, continuous data may also help understand the prognosis or dynamic nature of the illness affecting an older adult (Giger et al., 2015). The outputs from these monitoring systems can improve virtual support, preventive maintenance, and in-person consulting since they use information that AI algorithms have previously synthesized. For example, healthcare professionals accessing these automated systems' summarized outputs can switch from data entry and documentation responsibilities to therapeutic engagement and patient-focused activities during clinic visits (Ho, 2020).

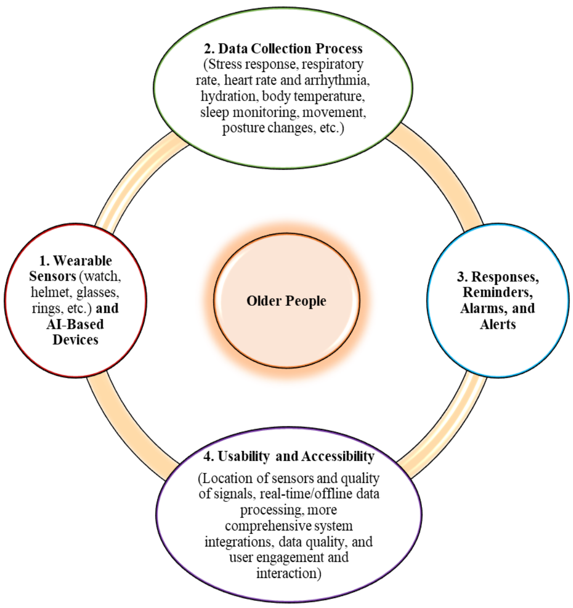
It is emphasized that older people and family caregivers experience a greater sense of security by using artificial intelligence-supported automatic monitoring systems at home and that these technologies are an acceptable alternative to face-to-face monitoring and follow-up in supporting the independent life of older adults. The data of elderly individuals obtained with artificial intelligence supports the medical decision-making process and helps healthcare providers to prioritize cases and improve the quality of care to ensure that elderly patients have timely access to appropriate care (Luo et al., 2018; Sriram et al., 2019; Ho, 2020). Automated monitoring systems that provide an in-depth picture of seniors' general activity patterns and the environmental circumstances in which different symptoms occur have become crucial tools for healthy aging. These instruments assist older people, family caregivers, and healthcare professionals with intellectual tasks. These technologies may further improve current care services, lessen the burden on caregivers, and raise the standard of care. Such advancement may help delay or eliminate the need for institutional care by promoting autonomy in the rapidly growing older population. However, AI-based health monitoring technologies are also crucial in fulfilling the aging demands of older adults while empowering them and improving their quality of life (Luo et al., 2018; Sriram et al., 2019; Ho, 2020).

Wearable Devices Based on Machine Learning

Along with implanted fixed devices utilized in hospitals, wearable devices can also include medical objects on the internet. The combination of AI-enabled Internet of Things and wearable devices is being used to solve some of the problems brought on by aging by monitoring older adults remotely and allowing them to do their daily activities without fear (Baig et al., 2019). The Internet of Things is a generally new concept that provides health monitoring through wearable devices. Wearable devices have come to the fore in monitoring older individuals' day and night without interruption and discomfort, quickly recognizing sudden changes in their health status and intervening. Wearable devices such as watches, glasses, chest straps, and rings by mounting different types of sensors on the body and capturing signals from the body (Baig et al., 2019). These gadgets have a network connection to enable remote contact with mobile devices. Numerous sensors, such as temperature, accelerometers, optical, and biometric sensors, are included in wearable technology to analyze various human signals continually (Liu et al., 2020; Stavropoulos et al., 2020). The field of wearable technology is actively being investigated to increase the convenience and usability of monitoring vital physiological indicators and occasionally psychological or emotional behaviors that can be recognized by analyzing data from various sensors. Medical device sensors and user interaction with these devices are acknowledged as a big data source from which features can be extracted for several healthcare and aged care interventions, such as disease diagnosis and health status assessment, allowing machine learning algorithms to detect and learn. Machine learning includes having wearable devices take action/decision without explicit programming for a particular scenario by learning from experience. Machine learning is often coded in terms of existing data, learning from experience, and data samples that may or may not be labeled. Studies to examine applying machine learning methods using body signals, discussed for health monitoring, aged care, and movement tracking, have increased in the last decade. In terms of nurses, machine learning includes especially fall detection, seizure detection, monitoring of vital signs, estimation and condition monitoring, and activity definition to determine daily activities. In addition, the use of wearable devices in stress detection and heart rate, arrhythmia detection, hydration monitoring, sleep monitoring, and rehabilitation tasks are also examined (Galambos et al., 2019; Baig et al., 2019; Stavropoulos et al., 2020).

Figure 1

Overview of Wearable Sensors and IoT-based Systems (Baig et al., 2019)



Artificial Intelligence-Based Robots

Technology is a trend that has an impact on human existence all over the world. Robots are an exciting example of the upcoming technology. Thanks to robotic technology, significant improvements are experienced in human life and industry (Baloğlu et al., 2019). Robots generally use AI techniques in internal software systems, especially machine learning with reinforcement learning, to interact and adapt to the world (Pu et al., 2019; Loveys et al., 2022). Therefore, robots, which serve primarily as an assistant to older adults, generally have an authoritarian function in supporting individuals to perform their care tasks without assistance. Care robots are technological devices generally integrated into healthcare workers or caregivers for care applications (Abbott et al., 2019). Elderly care robots are defined in different categories, such as assistive social robots and rehabilitation robots (Baloğlu et al., 2019) or healthcare robots that monitor physical assistance, companionship/friendship, and health status/safety (Broadbent et al., 2009). Assistant robots can be effective at home by performing various activities such as home monitoring, assistive device management, personal assistance, safe environment, risk sensing, and entertainment.

Both rehabilitative and social robots can be used to help relieve the pressure on aged care systems as the global aging population and their needs become an increasingly important problem for healthcare providers, government officials, and caregivers (Baloğlu et al., 2019; Pu et al., 2019; Loveys et al., 2022; Broadbent et al., 2009). Robots are deployed specifically to provide comfort and psychological support to older adults living in nursing homes to help them overcome the loneliness and depression they experience (Abbott et al., 2019). Assistive robots can guide prevention and prognosis by collecting data such as previous medical cases of an elderly individual along with clinical findings. Robots developed to date can provide bed bathing, dressing, standing up, and assisting in rehabilitating stroke patients (Lo et al., 2010; Baloğlu et al., 2019). On the other hand, more miniature robots can remind elderly individuals to take their medications, act as personal assistants at home, observe them, exercise, and manage their daily living activities (Baloğlu et al., 2019). Thanks to these technological features, the importance of artificial intelligence-based robots in improving elderly care services, increasing the welfare and independence of older adults living alone at home by functioning as health professionals or caregiver resources in hospitals and elderly care institutions is increasing day by day.

Artificial Intelligence-Based Smart Homes

Health-assisting smart homes have taken their place in the digital age as an option that can improve older people's independence. Smart homes are a cutting-edge technology designed to assist older adults age in place by monitoring their home movements and intervening on their behalf when necessary (Liu et al., 2016; Wilson et al., 2019). Collecting data on the daily lives of elderly individuals living in a smart home is necessary for autonomous operations with the AI algorithms of the home. Through the collected data, these algorithms determine the behavior of the elderly living at home and make predictions for the following action (Cakir et al., 2022). Smart homes use hardware and computer software to help maintain health and prevent disease. Computer-based algorithms are complex probability and statistics programs. Due to their ability to detect patterns in daily activity and human behavior, these are activity-sensitive algorithms (Cook & Krishnan, 2014). They instantly determine and categorize data from sensors intended to sense the state of an environment to accomplish this. Smart homes utilize various sensors, including infrared motion, door use (contact sensors), temperature, light, humidity, vibration, pressure, and others, to detect motion inside the home environment (Liu et al., 2016; Wilson et al., 2019). Each sensor offers specific information to understand clinically significant human behaviors and activities. These sensors are small, continuously monitored, affordable, and relatively easy to store and manage data (Cook & Krishnan, 2014). This combination of sensors is essential as the collected data provides a comprehensive picture of an older adult's movements and behavior at home without needing a camera or microphone (Cook & Krishnan, 2014). Additional sensors can be incorporated to enhance the capture of particular movements (behaviors and activities). Ground pressure sensors can offer data on falls and older people's gait and walking pace (Cook & Krishnan, 2014; Wilson et al., 2019). Vibration sensors may improve knowledge about ambient noise levels and equipment usage and aid fall detection (Cook & Krishnan, 2014). These various sensors are critical in providing the opportunity to be aware of the safety of older adults. Thanks to these systems, smart homes can quickly respond by sending SMS, e-mail, or phone calls with the emergency button, which is constantly exciting and can create special scenarios for older adults at home when necessary (Cakir et al., 2022).Many people use smart technology, including the smart home, to assist older individuals with their healthcare needs. The need for nurses to be at the forefront of incorporating new technology into patient care is growing (Fritz & Dermody, 2019; O'Connor et al., 2022). Despite the rigorous research work that nurses have done to support these technologies, particularly the integration of AI into complex systems such as modern healthcare, there appears to be a significant gap in the transfer of clinical knowledge from nursing to engineering. Further studies are needed to explain how nurses can guide AI education, such as smart homes, and how to incorporate clinical nursing knowledge into the education of AI algorithms designed to assist healthcare.

Artificial Intelligence Interventions Among Older Adults

Studies evaluating the effectiveness, risks, and attitudes toward developing and implementing AI interventions in older adults have gained importance in recent years. On the other hand, although gerontology nurses are not included in many studies examining how artificial intelligence can improve older adult health, the developed approach must be adopted in the use and care of health services. Bayen et al. (2021) developed and tested an AI-based video surveillance system among older adults with Alzheimer's disease. This monitoring system informed healthcare professionals in real-time and could respond quickly. As a result, AI-based monitoring systems help reduce the time older adults spend on the ground after falls. This type of AI-based system is essential to support gerontology nurses in their daily practice to help reduce healthcare costs while reducing secondary complications from falls and improving the post-fall prognosis of older adults. In another study, Al-Hameed et al. (2019) tested an AI-based speech recognition system at home in older adults at risk of developing dementia to determine whether linguistic changes indicative of the early stages of the neurodegenerative syndrome can be identified. These new approaches to preventive care should be considered as nurses can increase the care and support they provide for older adults and their families.

Interventions evaluating the potential of employing wearable devices to promote the success of healthy aging interventions have shown a significant improvement in physical function, cognitive performance, nutritional status, and depressive mood, among community-dwelling older people (Chen et al., 2020). Dolatabadi et al. (2019) reported on the viability of tracking the longitudinal gait of dementia-affected older people. It is crucial to monitor the gait of older people with dementia to ensure their safety. Further AI-based analysis may assist with the early detection of behavioral and mental disorders (Chen & Arai, 2020). One study demonstrated the short-term benefits of increasing physical activity in older adults using wearable devices. However, it has been reported that the effects on the older population and the long-term effects are uncertain (Liu et al., 2020). According to the study results, utilizing wearable devices to increase physical activity is inspiring, and the long-term effects should continue to be investigated in all populations. In another study, a data-driven machine learning model approach was used to create a multiple disease vulnerability index to predict the negative consequences of aging faced by older adults (Peng et al., 2020). AI-based approach's power in data analysis and outcome prediction; however, applying these findings to clinical practice is still complex for clinicians in this study. AI-based interventions captured vital outcome prediction variables and demonstrated the effectiveness of survival analysis to provide the best predictive results (Peng et al., 2020).

Studies have shown the potential of using AI-based emotional facial expressions, vocal cues, and language to early detect older individuals with potential risks for neurodegenerative diseases or dementia (Al-Hameed et al., 2019; Jiskoot et al., 2020). On the other hand, it is also essential to include robotic technology in care services due to the lack of an international caregiver workforce (Chen et al., 2020). Studies on robotic technologies seem to focus on the effectiveness of reducing behavioral and psychological symptoms in elderly individuals with dementia and the roles of social robots for people with depression (Abbott et al., 2019). Studies have reported that robots are friends with elderly individuals and positively increase elderly autonomy, social skills, and communication (Broadbent et al., 2009; Elsy, 2020). The critical point to be considered here is the communication and interaction problems between robots and older people. It is predicted that future care services will be unable to function without multitasking or task-specific robots that can assist older individuals with their daily living activities.

Limitations and Risks of Artificial Intelligence Interventions in Elderly Care

Despite all the advances in AI technology in elderly care, several concerns and risks are associated with AI applications in healthcare. The inability to individualize care due to algorithm-based standardization, prejudice against minority groups due to generalization, limiting the care connection through automation, and disciplining users through monitoring and surveillance are a few examples of such issues (Rubeis, 2020). Nevertheless, these possible threats underline the requirements and difficulties to be met when creating AI and gerontechnology-based services. Older consumers' viewpoints, knowledge, and comprehension of AI-based services are crucial in all circumstances involving the implementation of new technologies (Vandemeulebroucke et al., 2018; Rubeis, 2020). Algorithmic bias is a potential risk, as digital health datasets that train and test AI algorithms may be missing information from specific populations. Poor-quality datasets used to develop AI can skew predictive models and lead to inappropriate clinical decision-making. This can negatively impact older adult care and reinforce existing inequalities in healthcare (Chu et al., 2022). The retrospective nature of many health data sets on which artificial intelligence techniques are developed and the lack of critical variables that may affect older adult health in probability models may also reduce the ability to predict future events (Chin et al., 2019). Therefore, gerontology nurses need to be aware of the limitations of AI-based systems and continue to use their clinical expertise to support the care of older adults.

Along with these limitations and risks, some important ethical considerations for AI-enhanced interventions as part of healthcare have also been reported. Older people may have a variety of reactions to social robots. While it has been demonstrated that some older people get along well with robots, others are uninterested in them or react poorly because of increased baseline agitation (Vandemeulebroucke et al., 2018; Rubeis, 2020). Some technologies may put older people with dementia in danger of infantilization by tricking them into thinking the robot is a natural pet. Many older adults develop bonds with robots, and they may face psychological issues when separated. However, the severity and chronicity of the problem of separation from robots have not been sufficiently studied, and it remains unclear what strategies are appropriate to end older people's relationships with robots.

On the other hand, Stokes and Palmer (2020) also highlight several ethical issues that may be encountered when artificial intelligence is integrated into robotics. There are some concerns that robotic technologies may replace gerontology nurses or automate some aspects of their caring role. Robots lacking human emotions such as empathy could lead to less personalized care and poorer therapeutic relationships with older adults, compromising their physical, mental, and social health. Furthermore, personal privacy is another concern affecting the autonomy and well-being of older adults. Incorporating AI into robotics and home/remote monitoring technologies may lead to increased surveillance and possible inappropriate disclosure and use of personal information (Hasal et al., 2021). Galambos et al., (2019) assessed older adults' and their families' perceptions of using smart sensors. They emphasized that as people age, the advantages and disadvantages of using AI-based technologies should be considered by older adults and their caregivers. Many studies reported concerns about surveillance and data privacy (Vandemeulebroucke et al., 2018; Rubeis, 2020; Hasal et al., 2021). Therefore, robust data protection measures are crucial for accepting and adopting these technologies in healthcare.

Conclusion and Recommendation

At the point of provision of technological health care services to elderly individuals, they are collecting the data of older people in an environment and sharing them from this environment when necessary, providing care services that can be done remotely, using sensors and robots, and supporting these systems with artificial intelligence. Most artificial intelligence interventions in the older population focus on mental capacity, social participation, or psychosocial outcomes. Artificial intelligence applications developed, such as AI monitoring systems, diagnosis and early detection systems, wearable devices, robotic technologies, smart homes, have the potential to improve the quality of life of older adults, especially those living alone in institutions or at home, by focusing on helping elderly individuals in their daily life activities and managing their chronic health conditions. However, studies involving more AI interventions are needed to detect consequences, including frailty, falls, fractures, disease exacerbations, abnormal daily activities, neuropsychiatric symptoms, and changes in health status, especially in older people with multiple comorbid diseases.

Given the rapid development of AI in older adult care, gerontology nurses also need to have greater awareness and knowledge of this technological trend as it will impact their practice, and they can guide patients on using AI-based tools. Therefore, nurses need more educational opportunities to learn about the range of AI techniques available and how to apply them to datasets for the older population (Ronquillo et al., 2021). This knowledge will allow nurses to conduct AI research and assess whether these predictive algorithms can benefit clinical decision-making and patient care and whether it is worth introducing AI-based technologies into gerontology nursing practice. As nurses collaborate with colleagues in the computer science, engineering, and technology industry, they can encourage the active engagement of patients to help co-design AI-based tools to meet the needs of older adults (Blakey et al., 2020). As the digital age accelerates, the nursing profession, especially those working in gerontology, should embrace AI applications to help support and improve the health and well-being of older adults, considering the risks and ethical issues that AI interventions may pose.

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Similarity Index
The similarity index obtained from the plagiarism software for this book chapter is 15%.

To Cite This Chapter:
Gulbahar Eren, M. & Sert, H. (2023). Digital Transformation in Improving Elderly Health with a Nursing Perspective: Artificial Intelligence Interventions. In S.N. Guner, Y. Uzun & I. Cetin (Eds.), *Current Studies in Healthcare and Technology* (pp. 19–32). ISRES Publishing.

CHAPTER 3

Mobile/Web-Based Applications in Healthcare

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Mobile/Web-Based Applications in Healthcare

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Introduction

According to reports, the first mobile health applications were created in the 1960s to track the health of astronauts in space. Wireless devices that monitor an individual's heart rate while they are exercising were created in the years that followed, and with the advent of smartphones, mobile/web-based health applications began to gain popularity (Kopmaz & Arslanoğlu, 2018). The average life expectancy has increased as a result of health advancements, and the prevalence of chronic diseases has increased the workload of healthcare personnel. Healthcare services are rapidly evolving to handle this workload. The most significant aspect of this process of development and change in health is the use of mobile and web-based applications. A growing number of disease areas are using mobile/web-based applications, which the World Health Organization defines as "the provision of many applications in the field of health supported by mobile phones, patient tracking tools, personal digital assistants, and web-based applications" (Keutzer et al., 2020). It can be said that mobile or web-based health applications that adopt strategies such as taking responsibility for one's health after attending to the immediate health needs of the person who applies to the health institution to receive health services when he or she is ill, taking precautions to maintain his or her health and avoid becoming ill, carrying information about his or her health status with him or her, and using treatment protocols appropriate for the patient's genetic make-up and personality structure Teenagers and young adults frequently use smartphones and tablets. A variety of treatments and goals, such as knowledge growth and independent self-management abilities, can be addressed thanks to the multipurpose properties of smartphones and tablets (Virella Pérez et al., 2019). The workload of healthcare professionals diminishes at the same time as patient and healthy individual health awareness rises due to the widespread usage and expanded capability of mobile/web-based applications in health (Ghose et al., 2022).

For the technology used in all areas of life to be used more effectively and efficiently in the field of health, initiatives to increase the awareness of health professionals and society on this issue are gaining importance. Mobile/web-based applications in health continue to be used as supportive or complementary to many traditional applications used to date. Mobile/web-based applications, which continue to be used for different purposes in the field of health, are offered to the use of society and healthcare professionals with both advantages and disadvantages and changing usage types. While evaluation studies on the effectiveness of mobile/web-based applications in the field of health continue to increase day by day, there are many studies with high levels of evidence demonstrating the effectiveness of these applications (Farooqui et al, 2015; Castensøe-Seidenfaden et al., 2018; Le Marne et al., 2018; Aromatario et al., 2019; Virella Pérez et al., 2019; Lorca-Cabrera et al., 2020; McCloud et al., 2020).

Uses and Purposes of Mobile/Web-based Applications in Health Care

Mobile/Web-based applications are widely used in health promotion, diagnosis, clinical treatment and care, home care and follow-up, patient and staff training, counseling, and coaching. It is noteworthy that the rate of use of mobile/Web-based applications is affected by the development status of countries, and as science and technology progress, the rate and areas of use increase. For developed countries, remote disease management is used for nutrition, exercise activities, and electronic transfer of patient data to maintain health and well-being, while for developing countries it is used for purposes such as informing via mobile phone, raising awareness about diseases and disease prevention (Stach et al., 2020; Tezcan, 2016).

Remote monitoring of patients receiving outpatient or inpatient treatment and care services, monitoring their vital signs, and sharing them with healthcare professionals in a timely and instantaneous manner so that necessary interventions can be made without delay are important for both healthcare professionals and patients (Demir & Arslan, 2017). In a systematic review evaluating mobile applications used for diagnosis and treatment, it was determined that cameras, touch screens, and microphones were the most frequently used internal sensors, and it was reported that the topics addressed by these applications were respiratory, dermatology, neurology and anxiety-related health problems (Baxter et al., 2020). In a study examining the characteristics of mobile applications developed to improve lifestyle for chronic diseases, it was determined that the applications are mostly for the treatment of conditions related to many diagnosed chronic diseases such as diabetes mellitus, hypertension, cardiovascular diseases, asthma, and neoplasms. The main interventions were lifestyle changes, reducing body weight, promoting a healthy diet, and encouraging regular physical exercise. It was also concluded that simple messages and warnings to adhere to treatment facilitate health care (Debon et al., 2019). A clinical monitoring system based on color-coded alarm systems has been developed to monitor an entire unit or a bed in an intensive care unit according to the severity of patients' vital signs (Ventola, 2014). In a systematic review study examining smartphone applications developed for the care of patients with diabetes, it was found that the applications focused on reminder systems to encourage treatment adherence, patient information/education, collective information and gamification, processing of blood glucose data, and nurse coaching system via telephone (Fornengo, 2022). Mobile/web-based applications are useful to overcome problems such as difficulty in diagnosis, patient compliance, and lack of education, which are also problems in tuberculosis treatment (Keutzer et al., 2020). Counseling, sexual therapy, and self-management interventions through mobile applications have been shown to have positive effects on sexual health problems in chronic patients (Karim et al., 2020). In a study examining pediatric health behaviors and related outcomes of digital technology, behavioral issues such as vaccination compliance, HIV prevention, dental hygiene, sun protection, physical activity, smoking, obesity, diabetes, stem cell transplantation, and asthma were addressed as in adults (Virella Pérez et al., 2019). It can be said that mobile/Web-based applications can be applied for behavior change for both adults and children. Mobile/web-based applications are also used in orthopedics and trauma surgery patient groups for education and health information. However, it has been stated that disadvantageous situations such as the fact that the target audience consists of young people and the elderly cannot benefit from these applications (Reinecke et al. 2021). As a result of the articles analyzed from 19 countries to determine the scope of mobile health applications that help COVID-19 management, 29 mobile applications were identified. Among these, 15 (52%) applications were contact tracing, 7 (24%) applications were quarantine, 7 (24%) applications were symptom monitoring, and 1 (3%) information provision application. More than half (n=20, 69%) were developed by government sources, only 3 (10%) by private organizations, and 3 (10%) by universities. It was stated that these practices can be effective when adopted by the community (John Leon Singh et al., 2020).

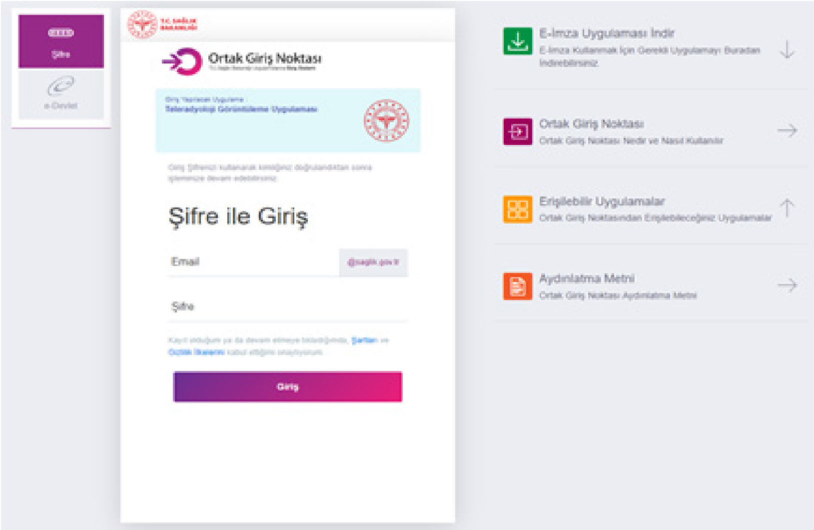
Types of Mobile/Web-based Application Usage in Health Care

In healthcare, there is a wide choice of apps that can help answer clinical practice and other questions at the point of care, such as drug reference guides, calculators, clinical guidelines, and other decision support aids, textbooks and literature search portals, and so on. There are even mobile apps that can perform simple examinations such as surgical simulations, hearing or vision tests (Ventola, 2014). Although there are many different types of use in health, mobile/web-based applications can be listed as telehealth applications, text messaging, smartphone applications, home care technologies, etc. (Tezcan, 2016).

With telehealth applications; health workers can provide home health services to individuals living in rural areas by communicating remotely with the patient or healthy individual. Telehealth applications enable clinical services to use information technology, video imaging, and telecommunication links to provide remote health services. Remote medical services include telemedicine, defined as the provision of medical services by a physician, as well as the services of professionals such as tele-nursing and tele-pharmacy (El-Sherif et al., 2022). Telehealth applications are mostly used in diabetes, hypertension, depression, heart failure, dementia, COPD/asthma, and kidney failure (Dogan Merih et al., 2021; El-Sherif et al., 2022). Telehealth applications have different clinical application modes such as simultaneous interaction, storing and transmitting data, remote monitoring, and telephone communication (Alvandi, 2017). In Turkey, telehealth applications started with services such as radiological reporting, ECG interpretation, reporting of pathology tissues, and consultation by planning services in the fields of radiology, pathology, and ECG. Today, the Ministry of Health carries out telehealth services with a focus on radiological reporting, teleconsultation, quality control, and e-Nabız integration. In this context, many hospitals have been included in the system. Examinations and evaluations have shown that thanks to the Picture Archiving and Communication Systems (PACS) system, approximately 65% of physicians have given up ordering additional radiology films (Sungur, 2020). For preventive healthcare services for the Syrian refugee population in Turkey, an application called HERA was launched in 2018, offering services in three local languages, namely Arabic, Turkish, and English (Narla et al., 2020). Various applications are offering similar services in many countries. For example, there are applications such as "Amwell, Zocdoc" developed in 2006 and 2007 in the USA, "Ping An Good Doctor" developed in 2015 in China, "MediQuo" developed in 2017 in Spain, "Vezeeta" developed in 2012 in Egypt, "Health Connect" developed in 2018 in Nigeria, "Yandex Health" developed in 2016 in Russia. There are many similar applications in the world (El-Sherif et al., 2022).

Figure 1

A Teleradiology Imaging Application in Turkey (Source: https://teleradyoloji.saglik.gov.tr/ Access: January 10, 2023)



Short messages (SMS) can be used for appointment reminders, chronic disease management, payment transactions, health alerts (vaccination time alerts, etc.), medication reminders, and transmission of data such as pain level and blood pressure to the health institution.

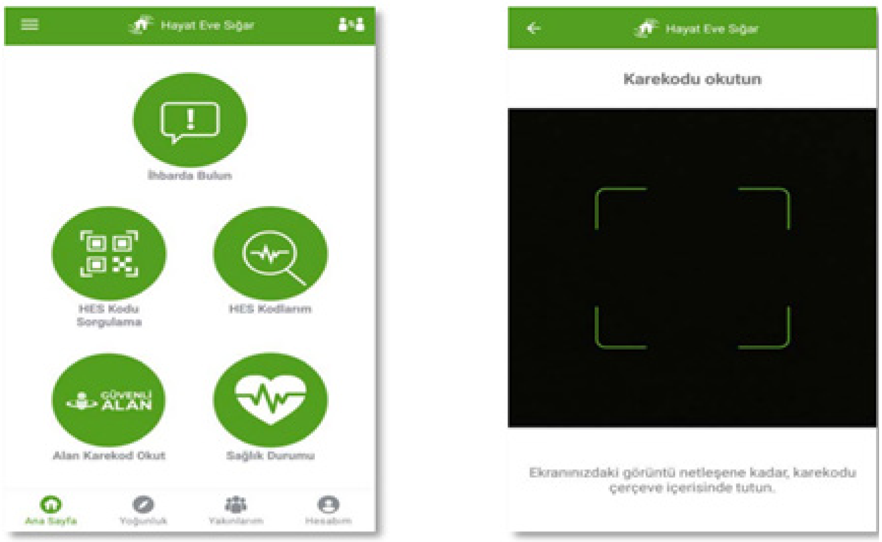
Figure 2

Short Message (SMS) from the Hospital (Source: https://www.ntv.com.tr/saglik/devlet-hastanelerinde-sms-donemi-basladi,34tyexpJBEWqlJd16SoNpg Access: 10 Ocak 2023)

Smartphone applications (mobile apps) enable real-time communication with the patient, enabling diagnosis and treatment. For example, there are smartphone applications that can detect visual impairments with the help of a phone or an external accessory (Ventola, 2014; Majumder et al., 2020; Aruljyothi et al., 2021). In addition, smartphones are used in public health applications, data collection in epidemics, more effective research planning, security of drug supply chains, ensuring drug compliance, more effective implementation of treatments, and many other innovative solutions (Lamonaca et al., 2015). In addition, interventions such as self-management, physical activity, and exercise programs can be easily done with smartphone applications (Güler & Eby, 2015; Byambasuren et al., 2019). During the COVID-19 pandemic, the Turkish Ministry of Health developed a mobile application called "Hayat Eve Sığar" (Life Fits Home), shown in Figure 5, to ensure the control of individuals in their environments and to monitor their vaccine quarantine and health status.

Figure 3

Hayat Eve Sığar Mobile Application (Source: https://hayatevesigar.saglik.gov.tr/HES.pdf Access: January 10, 2023).



With home care technologies; home care applications can be easily provided especially for patient groups over the age of 65, with diabetes, high blood pressure, heart failure, chronic lung diseases, and disabilities. Home healthcare services are provided through technological approaches such as artificial intelligence applications, telehealth, wearable technology, communication with medical devices, reliable home technologies, and care robots, virtual reality applications (Doğan Merih et al., 2021). Mobile/Web-based health applications enable patients who need home care to communicate with their doctors via video communication and to send their data regularly. Especially in cases where face-to-face home visits to individuals living in rural areas are prevented due to time, distance, and weather obstacles, transportation can be provided with home care technologies (Olver, 2005; Read Paul et al., 2019). In one study, mobile web-based video conferencing, which is a home care technology, was used to support elderly palliative care patients living in rural areas, and it was stated that this service, which is more effective than phone calls, has limitations such as low visual and audio quality compared to face-to-face visits (Read Paul et al., 2019). For examples of home care support systems in Turkey, https://apps.apple.com/us/app/aile-destek/id1606165366 and https://sesanltd.com.tr/saglik-bakanligi-evde-saglik-hizmetlerine-nasil-basvurulur/ links can be examined.

Advantages of Mobile/Web-based Applications in Health Care

Although there are many possibilities and opportunities for mobile and web-based health applications, one of the most crucial things to keep in mind is that applications and solutions do not always rely solely on technology. Mobile and web-based health applications are comparable in complexity to other health applications, it can be argued. Their advantages, however, are that they can be accessed remotely and make extensive use of communication and information technologies. Another benefit is that they give patients or healthy people the opportunity to control the process by taking an active role in their care. They allow for remote monitoring and reporting of people's health state in addition to serving as a communication tool for healthcare providers (Ardahan & Akdeniz, 2018). Applications for smartphones and the web can help remind users to take their medication on time and motivate them to exercise (Güler & Eby, 2015). The ability to communicate information and messages in real-time, provide remote monitoring, enable video conferencing between the patient and the healthcare provider providing care, and serve as a friend and reminder for the user regarding exercise, nutrition, and medication use are just a few benefits of mobile/web-based health applications (Güler & Eby, 2015). Additionally, according to Aromatario et al. (2019), using mobile or web-based applications can help to lessen health disparities. In the field of healthcare, mobile/web-based applications can assist with financial and administrative transactions, public health surveillance, professional training, and biomedical research, streamlining administrative costs and improving the health of the nation's population while also saving time in the education of healthcare professionals and both sick and healthy people (National Research Council et al., 2000).

Being responsible for a dependent person is often cited as a significant source of stress that can affect caregivers' health and quality of life. Mobile/Web-based applications can help empower caregivers of people with chronic diseases and develop solutions to reduce physical and psychological problems caused by caregiving (Lorca-Cabrera et al., 2020). Ploeg et al. (2017). (2017) reported that web-based interventions reduced depressive symptoms, anxiety, stress, and distress among caregivers of adults with chronic diseases (Ploeg et al., 2017). Sherifali et al. (2018) also reported that internet-based interventions improved the mental health of caregivers responsible for adults dealing with chronic illness, particularly depressive symptoms, stress, distress, and anxiety (Sherifali et al., 2018).

Smartphones and tablets provide easy access and use at the point of care with a single device, as they can be stored in a pocket with both computing and communication features. In addition to providing voice and text information, newer models offer more advanced features such as web search, global positioning systems (GPS), high-quality cameras, and voice recorders (Ventola, 2014). Cloud-based storage and file-sharing services, which can be accessed using a mobile device, are useful in information management as they allow users to store, update and share documents or photos with others without the need to use a flash drive or CD. Cloud-based information storage allows instant access to information from multiple devices, thus enabling people working together in healthcare to share materials quickly (Nguyen et al., 2019; Fellah et al., 2020). In summary, it can be said that the use of mobile/web-based applications in the field of health will lead to better diagnosis and treatment, individuals who can manage their health, increased preventive health practices, chronic disease follow-up, continuity of the health system, time savings for healthcare professionals and patients, and cost reduction by reducing hospitalization. Mobile/web-based applications, which offer unlimited possibilities and opportunities, should be used carefully and attentively in health service delivery, which is an important and risky area (Ardahan & Akdeniz, 2018; Tezcan, 2016).

Disadvantages of Mobile/Web-Based Applications in Health Care

Despite the fact that technology has gotten more affordable, one of its biggest limitations is cost due to the complicated question of who should pay for mobile and web-based health apps. For instance, many cloud-based storage systems used in mobile and web-based apps, which are useful for storing data, offer users several gigabytes of memory for free; however, users are frequently prompted to pay an annual fee for extra space (Xu et al., 2021). For many users, this can be a drawback. Because healthcare organizations use various applications that are incompatible with one another, patients are unable to access their medical information (Tezcan, 2016). For the information to be effective, it is crucial that social inequality be addressed as well as the user's degree of health and technological literacy. Individuals with low health literacy may not be able to use these technologies (Öney Doğanyiğit, 2015; Aromatario et al., 2019). Since personal data can be accessed by mobile/web-based health applications, strict security and privacy precautions must be taken to protect the confidentiality of data; otherwise, grave issues with personal data may occur. Users' lack of awareness of the fact that mobile/web-based health applications can only be helpful with consistent use and the danger of internet and phone use to the point of addiction is a drawback (Tezcan, 2016; Silva et al., 2018; Kayyali et al., 2017). The misuse of various diet and exercise programs provided by mobile and web-based health applications, particularly by those with chronic illnesses, can lead to a variety of health issues. Due to this, specialists in the field must create the content of such mobile/web-based health applications while adhering to the guidelines (Kopmaz & Arslanoglu, 2018). All age groups can use programs that are mobile or web-based. However, it can be said that usage rates decline as people get older. This may be considered a drawback, particularly for senior populations where the prevalence of chronic diseases is considerable (Reinecke et al. 2021).

Evaluation of the Efficiency/Effectiveness of Mobile/Web-Based Applications in Healthcare

The development of technology affects and determines how practices are carried out. Accordingly, healthcare professionals need to evaluate the impact of developing technology on health practices. There are short-term results related to mobile/web-based health applications and there are no long-term outputs, and time is required for the formation of sufficient outputs that prove efficiency/effectiveness (Ardahan & Akdeniz, 2018).

In a study that comprehensively evaluated the effect of mobile health applications on physical activity and eating behaviors on behavior change, it was stated that even when the applications were related to eating behaviors, the evaluations were tool-oriented rather than intervention-oriented (Aromatario et al., 2019). Mobile/web-based application studies with pediatric patients were examined and 78% of the participants found the "Young with Diabetes" application useful and 85% reported that they would recommend it to others (Castensøe-Seidenfaden et al., 2018), the participants of the "EpApp" application reported the information content and reminder themes of the application as the most useful feature (Le Marne et al, 2018), participants of the "Asthmahero" application used the application as a medication reminder, it provided patients' confidence and motivation in achieving asthma control, and 95% of the participants reported satisfaction with the application (Farooqui et al., 2015). In a study conducted in the United States, a storytelling intervention was conducted on a mobile/web-based platform to encourage HPV vaccination in women, and positive improvements were found in women's knowledge and attitudes toward HPV vaccination (Kim et al., 2020). Significant improvements in women's self-efficacy and quality of life were reported with a mobile/web-based self-management application for women with breast cancer experiencing chemotherapy-induced amenorrhea (Park et al., 2021). A mobile/web-based training program for pregnant women was conducted and it was concluded that the participants were generally satisfied with the training, but they reported that there should be more training content on dealing with emergencies that may occur in infants and newborn care (Kim & Kang, 2019). With an application called "ScreenMen" developed to encourage health screening in men, it was reported that men's desire for health screening was increased and that the application was useful and users' satisfaction levels were high (Teo et al., 2019).

To evaluate the application developed in our training study given with a mobile application to improve the supportive care needs and quality of life of women with breast cancer, the patient evaluation form, the supportive care needs scale (Aksuoğlu & Şenturan, 2016) and the World Health Organization quality of life scale (Eser et al., 1999) and the questionnaires for evaluating the application created by the authors were used. "The Effect Of Training Performed Using Mobile Application On Supportive Care Requirements And Quality Of Life In Women With Breast Cancer: Randomized Controlled Study", a mobile application was developed. Mobile applications developed in preparation for the study were examined. The educational content to be placed in the application was prepared, and factors such as whether the application serves the purpose, whether it is related to the care needs of the target group, the comprehensibility of the language, font, contrast, easy-to-use, simple and plain design, and the comprehensibility of the menu and icons were taken into consideration. Expert opinion on the content of the training and the application was obtained before the implementation of the study. Patients were included in the group that received opinions. It was determined that there was a consensus among the experts regarding the appropriateness of the scope of the mobile application and that the expert opinions were compatible with each other. After it was determined that Kendall's Wa coefficient of concordance was $W=0.180$ ($p<0.05$, $\chi2=44.340$), the application was offered to the users (Balci & Faydali, 2023).

The application, which we call **My Breast Health,** is in Turkish. It consists of seven interfaces: "Edit Password and Information", "How I Feel Today", "Daily Tips", "Training", "Forms and Scales", "About Us", "Resources". User login and interfaces were controlled through the "Admin Panel". Users registered to the application with a username and password that they set themselves. After the user registration was approved by the Admin Panel, the use of the application became active. Users' access to the mobile application and completion of the training content could be monitored throughout the study. **My Breast Health** mobile application admin panel and mobile application interfaces are given below as pictures. Images can be used regarding the chapter (Balcı & Faydalı, 2023).

Figure 4

My Breast Health Mobile Application Admin Panel

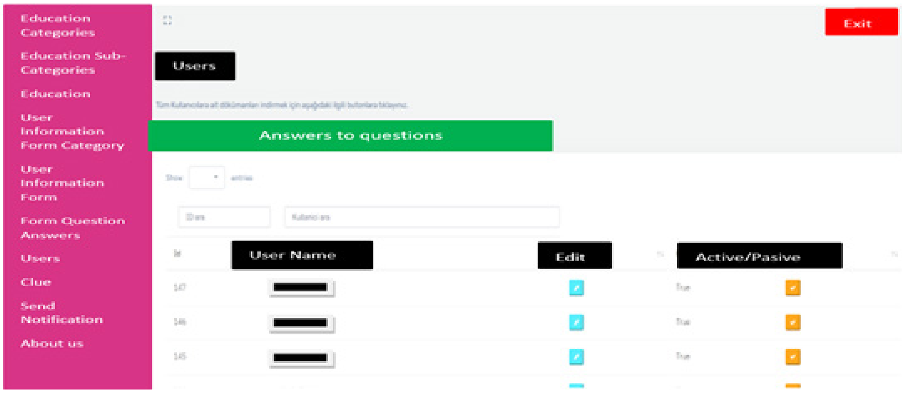
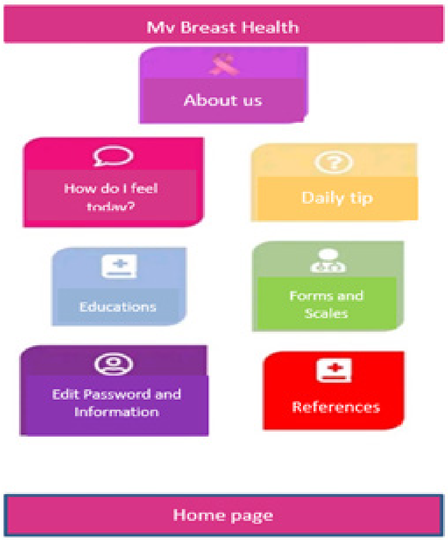


Figure 5

Interfaces of the mobile application



Interface 1; ***Edit Password and Information.*** This is an interface for women to edit their passwords and information.

Interface 2; How am I feeling today? Women were asked to indicate whether they had any problems or care needs daily.

Interface 3; Daily Tip. When a patient logged in to the application (to better manage symptoms), a daily tip was sent by the researcher about the solution suggestions for the most common problems mentioned in the training content and the subject that the patient marked as needing care.

Interface 4; Training. This interface included training topics shaped in line with expert opinions.

Interface 5; Forms and Scales. The scales and forms to be filled in by the patients were presented through the mobile application.

Interface 6; About Us. This interface explains the purpose and content of this application. It also provides information about the researcher (Balci & Faydali, 2023).

At the end of the study, women who experienced the My Breast Health mobile application were asked about their opinions with positive and negative statements about the training content and the application. The evaluation results of the patients after the study are given in Table 1. It was determined that the majority of women who evaluated the mobile application were satisfied with the mobile application and found it useful. As a result of the study, the supportive care needs of patients using the mobile application decreased positively and their quality of life increased significantly ($p<0.05$) (Balci & Faydali, 2023).

Table 1

Evaluation of Mobile Application and Education (n=41)

Opinions on the content of the training	**Yes**	**Unde-cided**	**No**
	n (%)	**n (%)**	**n (%)**
Was the language of the training clear?	41 (100)	0 (0)	0 (0)
Was the content of the training adequate?	40 (97,6)	1 (2,4)	0 (0)
Did the training cover your care needs?	40 (97,6)	1 (2,4)	0 (0)
Did the mobile application meet your information needs?	40 (97,6)	0 (0)	1 (2,4)
Were the topics provided with the mobile application understandable?	40 (97,6)	1 (2,4)	0 (0)
Were the visuals of the training explanatory?	38 (92,7)	2 (4,9)	1 (2,4)
Opinions on the mobile application			
Did the mobile app serve its purpose?	40 (97,6)	1 (2,4)	0 (0)
Was the typeface of the mobile app appropriate?	40 (97,6)	1 (2,4)	0 (0)
Was the contrast of the mobile application sufficient?	40 (97,6)	0 (0)	1 (2,4)
Was it easy to switch between application interfaces/screens and/or easy to use?	40 (97,6)	1 (2,4)	0 (0)
Were the main menu icons of the mobile application understandable/easy to use?	40 (97,6)	0 (0)	1 (2,4)
Did you find the mobile application reliable?	40 (97,6)	0 (0)	1 (2,4)
Were you satisfied with the communication through the mobile app?	40 (97,6)	1 (2,4)	0 (0)
Were you satisfied with the reminders?	40 (97,6)	0 (0)	1 (2,4)
Was the mobile app content readable?	39 (95,1)	0 (0)	2 (4,9)
Were you satisfied with the mobile interaction?	39 (95,1)	2 (4,9)	0 (0)
Was the design of the app simple and straightforward?	39 (95,1)	1 (2,4)	1 (2,4)
Were you able to concentrate while using the mobile app?	38 (92,7)	3 (7,3)	0 (0)
Was the mobile application advantageous?	38 (92,7)	3 (7,3)	0 (0)
Were the topics given with the mobile application memorable?	38 (92,7)	2 (4,9)	1 (2,4)
Are you satisfied with using the mobile application?	37 (90,2)	2 (4,9)	2 (4,9)
Was the performance of the mobile application adequate?	33 (80,5)	2 (4,9)	6 (14,6)
Was it visually big enough?	27 (65,9)	0 (0)	14 (34,1)
Was the mobile application easy to install?	26 (63,4)	2 (4,9)	13 (31,7)
Would you prefer face-to-face training to mobile application?	23 (56,1)	9 (22)	9 (22)
Would you like the training to continue with the mobile application?	19 (46,3)	3 (7,3)	19 (46,3)
Did you need support in using the mobile application?	13 (31,7)	2 (4,9)	26 (63,4)
Were there any disadvantages of the mobile application?	8 (19,5)	5 (12,2)	28 (68,3)
Did you think that your privacy was violated in the mobile application?	5 (12,2)	0 (0)	36 (87,8)
Did you have any problems with the mobile application?	5 (12,2)	1 (2,4)	35 (85,4)
Was the mobile application complicated?	2 (4,9)	1 (2,4)	38 (92,7)

Conclusion

Notably, both patients and medical professionals' benefit from the use of mobile and web-based applications in healthcare. In order to reduce effort and time, mobile and web-based applications should be made available to healthcare professionals as well as patients. Within the purview of governments and health ministries, applications can be created for both small-scale and large-scale studies. It is believed that once the service is made available to vast numbers of people, the cost will drop and the ongoing usage of applications may be secured. It is advised that attempts to develop new technologies in this area as well as evidence-based research assessing mobile/web-based applications be extended.

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To Cite This Chapter:

Balci, H. & Faydali, S. (2023). Mobile/Web-Based Applications in Healthcare. In S.N. Guner, Y. Uzun & I. Cetin (Eds.), *Current Studies in Healthcare and Technology* (pp 33–48). ISRES Publishing.

CHAPTER 4

Ethics in Health Technologies

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Ethics in Health Technologies

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Introduction

The sector of health has seen significant change and alteration as a result of technological advancement (Hayran, 2019). It is stated that the use of technology in the field of healthcare has enhanced communication between patients and healthcare providers, patient success in controlling their treatment, disease symptoms being better controlled, and patient satisfaction and healthcare quality rising (Korhonen et al., 2015). In addition to these positive aspects, there are a number of drawbacks as well, including risks to patient safety, violations of human rights, an increase in healthcare delivery disparities, rising costs, an increased reliance on technology, adjustments to personal norms, and social pressure (Hayran, 2019; Bulbul, 2022). The necessity for ethics in the healthcare system is growing daily as a result of these negatives (Tosun, 2021). Technology-using healthcare practitioners face moral conundrums about matters like morality, sensitivity, autonomy, and providing quality treatment (Korhonen et al., 2015). When considering health, decent care, wellbeing, uniqueness, and autonomy, morally sound choices can be made (Nagel et al., 2013). Guidelines must be set in order to lessen ethical issues with the use of health technologies. The inclusion of fundamental ethical principles including individual values, human rights, autonomy, privacy, nonmaleficence, beneficence, justice, and informed permission is advised for these guidelines (Chambers & Connor, 2002).

The Concept of Ethics

Ethics, which is one of the most difficult terms to define in today's rapidly changing individual and social life, is used synonymously with the words morality and moral (Tosun, 2016). Although the approaches to ethics and the meanings of related concepts have varied among philosophers and ethicists over time, especially I. Kant, J. S. Mill, and G. E. Moore were influential in the definitions of ethics in the 20th century (Butts & Rich, 2022).

Ethics, which is derived from the Greek word "ethos", corresponds to meanings such as custom, tradition, custom, habit, and established state of affectivity. Ethics is the field of study of the phenomenon called morality and is the theory of right and wrong behavior (Ustun, 2021). Ethics is a systematic approach to understanding, analyzing, and distinguishing between right and wrong, good and bad, admirable and dishonorable issues (Butts & Rich, 2022). In another definition, ethics is defined as "a branch of knowledge that aims to reveal knowledge about the relationship between people, to bring answers to various ethical problems with this knowledge, and to show people the possibilities of knowing about action" (Terakye & Ocakci, 2013). The Turkish Language Institution (TLI, 2023) defines ethics as "the science of ethics" and "a set of behaviors that the parties in various professions should follow or avoid".

As a humanistic field, ethics directs actions toward truth and good. At the same time, it guides the solution of ethical problems with vital values and investigates moral reasons (Okuroglu et al., 2014). Among its aims are to explain the moral nature of behaviors in human life, to raise awareness of the individual and society by bringing a critical perspective to behaviors, to create scientific foundations for the science of ethics, to show that individuals cannot be individual in their behaviors, but that they are indispensable elements of being an individual and their existence, and to teach to love people (Ozdemir Aydın, 2021).

Ethics plays an important role in determining the objectives, rules, and rules of a profession (Tosun, 2016). Ethical rules specific to any profession inform both the members of the profession and society about the values and ideals of the profession. In addition, it guides the members of the profession in the solution of ethical problems encountered and is a guide for creating a professional identity (Dinc, 2009; Uysal Kasap & Bahcecik, 2020). Medical ethics is a set of values that answer the question of evaluating the medical actions to be applied by health professionals in terms of good or bad and what should be done to behave well and what should be done to avoid bad behavior (Bilgin & Kucukhazar, 2015). Health professionals benefit from ethical principles in answering questions such as "What can I do and how can I do it best?" (Tosun, 2016).

Ethical Principles

Ethical issues are generally evaluated with ethical principles. Ethical principles are the rules that are accepted as basic and clear moral truths that are intended to be transformed into behavior and guide the action to be taken. These principles include autonomy, nonmaleficence, beneficence, privacy and confidentiality, justice and equality (Okuroglu et al., 2014).

Autonomy

In health practices, autonomy means the ability of the patient to make decisions over his/her own body, to determine his/her destiny, and to determine his/her own good following his/her values (Nesipoglu, 2022). There are four basic elements in the concept of autonomy. The first is that the autonomous person is respected, the second is that the individual can set personal goals, the third is that the individual can decide on a plan of action, and the fourth is that the individual has the freedom to take action in line with his/her preferences. In line with the principle of autonomy, patients should be informed about the possible outcomes, alternatives, and risks of treatments and their informed consent should be obtained to freely consent to treatment (Burkhardt & Nathaniel, 2013).

Nonmaleficence

The principle of nonmaleficence is related to the principle of beneficence. It includes intentional harm, the risk of harm, and harm done during the act of beneficence (Bakır, 2020). According to this principle, health services should be provided to minimize potential harm and maximize benefits (Burkhardt & Nathaniel, 2013; Nesipoglu, 2022).

Beneficence

This principle, which includes preventing and eliminating harm and deciding in favor of benefit (benefit) in the benefit-risk (benefit-loss) calculation, aims to achieve absolute benefit. In cases where a decision cannot be made in favor of benefit, balancing benefit and risk is recommended (Nesipoglu, 2022). The three main features of the principle of beneficence are doing good or promoting good, preventing harm, and eliminating evil and harm (Burkhardt & Nathaniel, 2013).

Privacy and Confidentiality

This principle, which is very important in the relationship between health professionals and patients, is among the fundamental individual rights. In line with this principle, information that is private to the individual to whom healthcare services are provided and which is desired to be kept confidential is not shared with third parties (Yılmaz Coskun, 2021). The right to privacy is based on autonomy and respect for human beings. Patients have the right to expect that their personal and private information will not be shared unnecessarily among health professionals (Burkhardt & Nathaniel, 2013).

Justice and Equality

Although it is the most violated ethical principle, it requires an equal and fair distribution of resources by considering the equality and rights of individuals (Yılmaz Coskun, 2021; Tosun, 2021). In the context of healthcare ethics, this principle focuses on the distribution of goods and services. This practice is called distributive justice (Tosun, 2016; Burkhardt & Nathaniel, 2013).

Electronic Recording Systems and Ethical Issues

Personal health records are sensitive and critical data included in the personal data section of laws and regulations. With the widespread use of computer communication technologies in institutions, health data are archived as Electronic Health Records (EHR) in health information systems (İleri & Uludag, 2017). EHR is an information system in which all health information of individuals is kept in a computerized environment from the time a person is born until the time of death. These systems are structures that ensure that each patient is matched with only one record, that contain health data such as diagnosis, diagnosis, treatment, result reports of the patient, and that these records can be accessed within the institution and from outside the institution when necessary, as well as an appointment system (Ministry of Health, 2023).

Personal medical health data are collected in institutions and organizations such as family medicine offices, hospitals, branch hospitals, medical centers, tissue banks, pharmacies, dentistry health centers, etc. Health records contain sensitive and critical data such as socio-demographic information, information on physical and mental health, financial and insurance information, prescriptions, infectious diseases, and physical abuse. Security, confidentiality, and privacy violations in health records containing these sensitive and critical data are increasing day by day. These situations cause legal and ethical problems (Eke et al., 2018; Toygar, 2018; Ucar & İlkılıc, 2019).

Ensuring the security and confidentiality of electronic health records is of utmost importance. These records should not be corrupted, accessed by unauthorized persons, or lost. When the security of the records is not ensured and misuse occurs, it may cause negative situations for the patient. The protection of health records is a shared responsibility of health professionals (American Nurses Association (ANA), 2023). Many national and international legal regulations have been made to ensure the security and confidentiality of records. Legal regulations are made to control the risks that occur in health records and to ensure the privacy and security of personal medical data (Ögütcü et al., 2011; Pakis Cetin & Cevik 2021).

Some of the measures to be taken to ensure privacy and security when transferring and storing health records to electronic media are as follows:

- Health professionals should be aware of their responsibilities under the legal regulations in their countries and be encouraged to apply professional ethical principles
- Taking technical and physical measures (using strong and secure passwords, security shields, virus protection programs, etc.)
- Organizing regular training to ensure the security of health records
- Obtaining permission from the patient and family for the transfer and use of health records (Ay, 2008; Ögütcü et al., 2011; Burkhardt & Nathaniel, 2013).

Use of Artificial Intelligence in Health and Ethical Issues

According to Kücükvardar et al. (2020), artificial intelligence is a system that autonomously completes tasks that are believed to require intellect from a human. Artificial intelligence is applied in the healthcare industry in a number of areas, including disease detection, patient assessment, therapy, and nursing care (Ozdemir & Bilgin, 2021). Although quick diagnosis and a decline in diagnostic errors are two advantages of artificial intelligence, it may also have drawbacks, like inhumanity when providing healthcare services. As a result, ethical issues may arise with the employment of artificial intelligence in the healthcare industry (Guvercin, 2020). Some of these problems are:

- Since access to artificial intelligence applications is costly, it causes problems with equal use and access to health services
- Artificial intelligence applications are likely to make erroneous decisions
- The question of "Who will be responsible when artificial intelligence applications make mistakes?"
- Ensuring the security and confidentiality of sensitive and critical data
- Problems in protecting human dignity and social isolation in health care
- Problems in the development of artificial intelligence technology
- Situations such as the use of artificial intelligence applications by malicious people lead to ethical problems (Burton et al., 2017; Guvercin, 2020; Ozdemir & Bilgin, 2021).

The rapid development of artificial intelligence applications in the field of health brings with it unforeseen risks. Investments should be made in this field and manpower should be provided. Ethical problems should be taken under control by developing national and international policies for the ethical issues raised by artificial intelligence programs (Cagatay, 2019; Kucukvardar et al., 2020).

Stem Cell and Ethical Issues

Today, the use of embryos in stem cell research is one of the most controversial issues due to its ethical and legal aspects. Where embryos should be obtained from and how many embryos should be harmed for the studies cause ethical debates. The medical world has different answers to the questions "At what stage does life begin?" and "Can the embryo be considered a human being?". These questions, which do not yet have a common answer, also cause ethical debates (Cavusoglu et al., 2017).

The right to life is one of the fundamental rights and freedoms that individuals have. Scientists who argue that life begins with the union of reproductive cells recognize the embryo as an entity with human rights. The zygote has the right to life upon fertilization. Those who hold this view argue that the use of stem cells for research purposes is ethically unacceptable. Some scientists, on the other hand, believe that it is ethically permissible to use embryos obtained from in vitro fertilization for research purposes, as well as surplus embryos that are not transferred. Scientists who hold this view do not recognize the right to life as an absolute right. Scientists argue that embryonic stem cells used to treat incurable diseases may limit the right to life. In contrast to these two different views, scientists who try to find a middle ground believe that even if an embryo is not recognized as a human being, it should be granted a special right. Those who hold this view do not accept research with embryos without any limits. Scientists argue that under certain conditions, studies should be carried out for human benefit (Bilgin, 2011; Cavusoglu et al., 2017; Kirici et al., 2020).

Another ethically controversial issue in stem cell studies is cloning. Cloning for reproduction in humans is against the human dignity and uniqueness of human beings. Human cloning is prohibited by international declarations and treaties (Amanak & Kavlak, 2013).

Assisted Reproductive Methods and Ethical Issues

Assisted reproduction methods enable infertile couples to have a child. In these applications, sperm and egg cells taken from donors are artificially fertilized under appropriate conditions and implanted into the woman's uterus. Another assisted reproduction method is surrogate motherhood. However, these methods lead to ethical debates (Can et al., 2016). One of these is the storage and freezing of extra spare embryos in case of failure during implantation. The use of human embryos for non-reproductive purposes is an ethical issue. If the embryo transfer is successful the first time, the treatment of the spare embryos and the rights/rights of the embryos cause ethical debates (Cavusoglu et al., 2017). Another controversial issue is that children may face more risks in assisted reproductive technique pregnancies compared to natural pregnancies. Especially since the risk of multiple pregnancies increases, problems related to multiple pregnancies (preterm birth, low birth weight) increase (Amanak & Kavlak, 2013).

Around the world, there is a sizable ethical discussion on the topic of surrogate motherhood. Surrogacy proponents hold that people's autonomy and the right to procreate should be recognized. Scientists that have a different perspective contend that surrogacy is not a right and is instead connected to people's desire to procreate. The birthright of the child is violated when a person exercises their right to procreate without regard for moral considerations. Ethics discussions are sparked by the child's wish to be born via surrogate mother, the child's right to know his or her biological parents, the right to donor confidentiality, and the psychological and social issues the child will face after knowing about the circumstance. From the surrogate mother's point of view, renting the female body and buying the child to be born are ethically discussed (Kenney & McGowan, 2014; Kirici et al., 2020; Kus Ozbek Guven, 202). Individual reproduction is possible through assisted reproductive techniques including egg and sperm donation and surrogate parenting. This causes the genealogical tie, that is, the bond between family members to be broken (Kus & Ozbek Guven, 2021).

Conclusion

In conclusion, it is inevitable that healthcare technologies will be used in the delivery of health services as science and technology advance. The contribution of health technologies to service delivery is growing daily. Despite the fact that this rise offers a lot of benefits for the patient, it has also raised a lot of questions. Using ethical principles as a guide is one of the most crucial methods to deliver high-quality healthcare services while maintaining patient safety. These values include justice, autonomy, beneficence, nonmaleficence, and privacy. The use of technology for the benefit of patients will be improved by health professionals who have embraced ethical principles, have high ethical awareness, have developed ethical decision-making abilities, and have a humanistic perspective.

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To Cite This Chapter:
Su, S. & Kose Alabay, K.N. (2023). Ethics in Health Technologies. In S.N. Guner, Y. Uzun & I. Cetin (Eds.), *Current Studies in Healthcare and Technology*(pp.49–58). ISRES Publishing.

CHAPTER 5

Multi Organ Segmentation in Medical images

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Multi Organ Segmentation in Medical images

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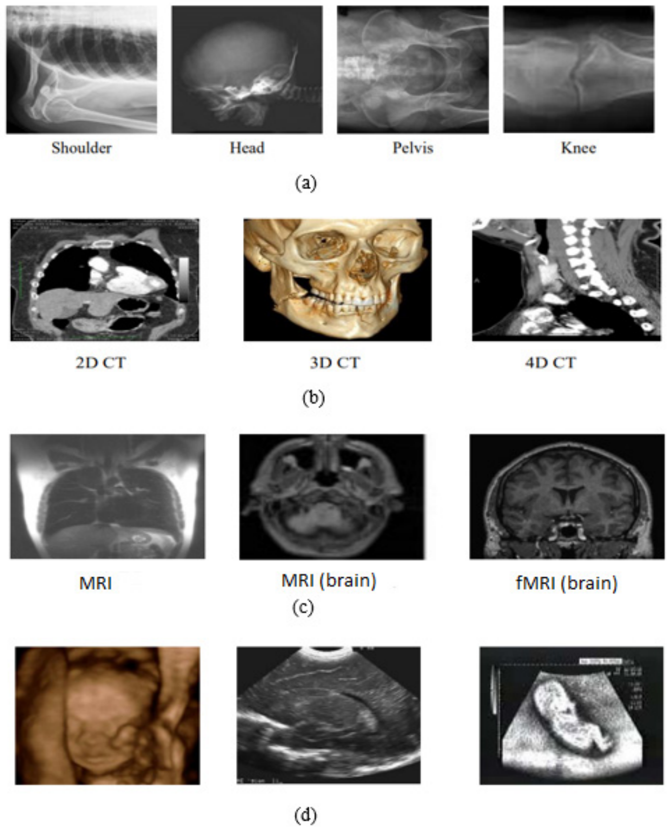
Introduction

In recent years, research in computer vision, image processing and pattern recognition have increased significantly. Computer vision techniques are very effective in the fields of health and medical research. Medical imaging with computer vision has a significant impact on healthcare applications (Gao et al., 2018; Ulhaq et al., 2020). Medical imaging enables the structure of the human body to be viewed with different techniques to obtain information about the state of the organs and to determine the areas that need intervention. Medical imaging is important in diagnosing diseases, at the same time it provides a treatment plan by examining the progression and spread of the disease (Atlan & Pençe, 2021). X-ray, computed tomography (CT), magnetic resonance (MR), ultrasonography (US), which are medical imaging methods, are used in the diagnosis of Nuclear Medicine diseases. Examples of medical imaging methods are given in Figure 1. X-ray is the first medical imaging management with X-rays. The human body has a 3-dimensional (3D) structure, including width, height and depth. However, on the images of X-ray films, the structures in this depth are overlap. The CT imaging method uses X-rays, as in the X-ray method. This method provides a three-dimensional image by displaying the body in the form of cross-sections and eliminates the problem of overlapping depth information in images obtained by the X-ray method. CT Imaging method provides more detailed information than X-ray imaging. In the MR method, a three-dimensional image is obtained using radio waves and in the form of sections, as in CT images. In the US method, the imaging process is performed using high-frequency sound waves. In nuclear medicine, a chemical compound is injected into the patient through the mouth or breathing. As the compound radioactively decays in the body, the image is produced by the emitted X-rays or gamma rays (Ozekes, 2006).

Figure 1

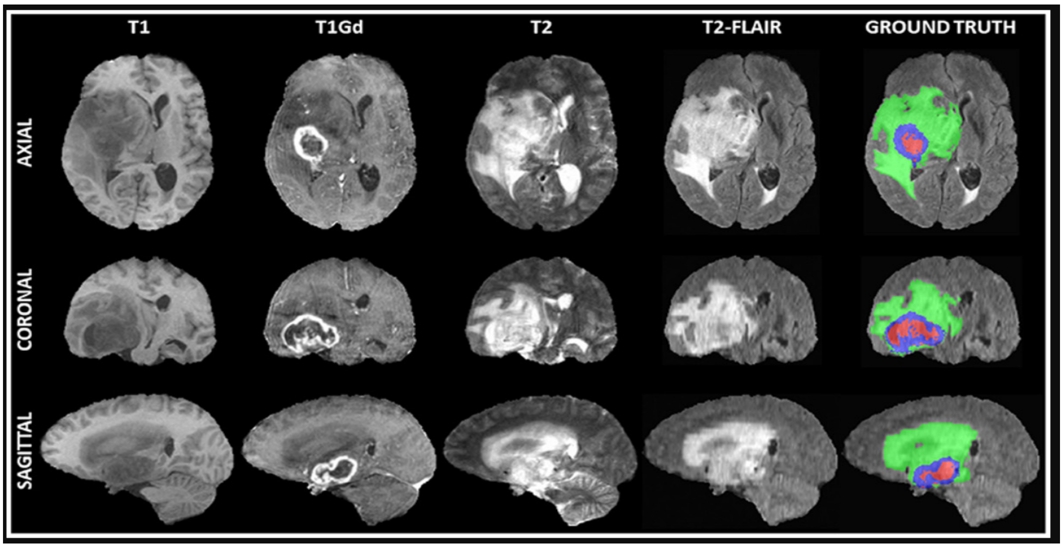
Examples of (a) X-ray image, (b) CT image (c) MRI image (d) Utrasound image (Kasban et al., 2015)



Analysis of images obtained by radiological methods helps physicians to understand internal anatomy and therefore plays an important role in medical application. Segmentation in medical images is an important issue. Image segmentation is the manual or automatic extraction of the region of interest in an image. Tissue and organ segmentation is performed on medical images (Norouzi et al., 2014). Figure 2 shows an example of segmentation on 3D MR images. Accurate segmentation of organs in medical images requires experience and takes a lot of time. The variability and complexity of anatomical structures in the human body has caused medical image segmentation to remain a difficult problem. Therefore, computer-aided systems that perform this process automatically have become necessary (Ma et al., 2021). Traditional methods and machine learning methods is used to automatic segmentation of medical images. Deep Learning ,the machine learning based methods, which have emerged as a subfield of machine learning, show the highest performance in medical image segmentation, especially in multiple organ segmentation (Fu et al., 2021). In this chapter, deep learning methods for segmentation in medical image are explored, especially based on segmentation of multi organ. Also, a study for multi organ segmentation is given.

Figure 2

Example of Segmentation on 3D MR Images (Reina et al., 2020)



Deep learning in Multi-Organ Segmentation

Before deep learning models became popular, multi-organ segmentation used traditional and atlas-based methods. Traditional image segmentation uses mathematical models that manually extract features from the image and detect lines, edges (Fu et al., 2021). In atlas-based methods, manual labeling is done for segmentation. Based on these labels, an image record is created. Segmentation is performed by applying statistical methods to the image records. However, the differences in organs in the image records make segmentation difficult in terms of computation (Conze et al., 2021). To overcome this difficult situation, Deep Learning-based methods that do not require image record have been widely used for multiple organ segmentation in recent years and have achieved successful results (Lei et al., 2020).

Deep learning emerged as a sub-branch in machine learning. Performance in machine learning methods depends on the features extracted from the data. Processing large and complex data is very time consuming and difficult, which has led to the inadequacy of machine learning and the emergence of deep learning models. Deep learning models are based on artificial neural networks. Deep artificial neural networks consist of many layers by adding neural networks one after another. Deep learning is done by training these deep neural networks by extracting features from the data imported into the network thanks to nonlinear layers. The output obtained from each layer in the training phase is used in the next layer. After the training phase is complete, the unlabeled data is labeled using the extracted features (Dargan et al., 2020). There are several deep learning architectures used for multi-organ segmentation. These deep learning architectures are divided into pixel-based classification and end-to-end segmentation. In this chapter, Convolutional Neural Network (CNN), which performs pixel-based classification, Fully Convolutional Networks (FCN), U-Net and Region-based CNN (R-CNN), which perform end-to-end segmentation, are presented (Fu et al., 2021).

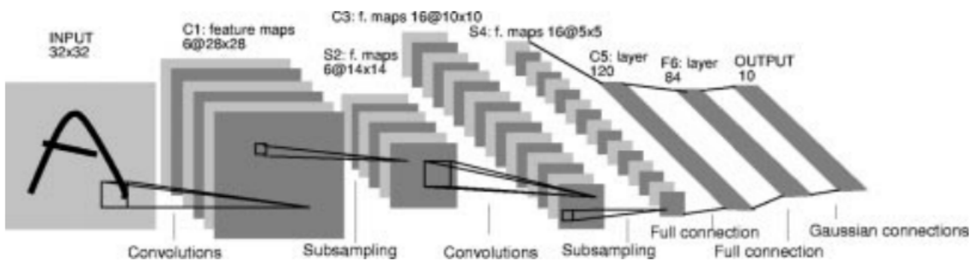
Convolutional Neural Network (CNN)

The first CNN architecture was designed by Yann LeCun in 1989 (Le Cun et al., 1989). This architecture, developed by 1998, was called LeNet (LeCun et al., 1998). LeNet architecture is given in Figure 3. In the following years, more advanced CNN architectures have been proposed. Convolutional neural networks (CNN) are multilayer architectures consisting of convolution layers, usually nonlinear layers, batch normalization, pooling layers and fully connected layer. The convolution layer is the base layer of neural convolutional networks. Thanks to this layer, the feature map of the images is extracted, and there is more than one convolutional layer. New features are extracted from the input image by applying different convolution operations to the previously extracted feature maps (Guo et al., 2017). The pooling layer gradually decrease the size of the extracted feature vector of the given inputs. This reduction reduces the number of parameters to be computed by the model, thereby reducing computational costs and eliminating complexity (O'Shea & Nash, 2015). It consists of a nonlinear layer activation function in a CNN. The activation function helps to learn complex data. Choosing an appropriate activation function allows the model to learn faster and perform better. This layer converts an input into a nonlinear output (Khan et al., 2020). The batch normalization layer usually comes after the activation functions in deep neural networks and normalizes the inputs to a mean of zero and a fixed standard deviation (Bjorck et al., 2018). The last layer in a convolutional neural network is the fully connected layer. Fully connected layers resemble a classical neural network. It take the feature vector extracted from the previous layer, analyze it globally, and form a nonlinear combination for classification (Albawi et al., 2017; Khan et al., 2020).

While basic concepts such as edge, light and color are learned in the first layers of CNNs, the characteristics of the objects are learned in the next layers (Dargan et al., 2020). CNNs have sparse connections, so they have fewer parameters than a fully connected neural network with the same depth. Training in CNNs is performed using a gradient-based learning algorithm. Thanks to these algorithms, the generated weights are optimized by minimizing the loss (Alom et al., 2019).

Figure 3

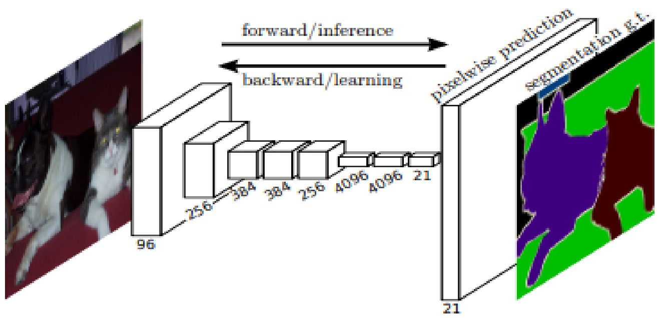
LeNet Architecture (LeCun et al., 1998)



Fully Convolutional Networks (FCN)

The fully connected layers in classical convolutional neural networks cause the spatial information of the image to be lost. Since spatial information is important for image segmentation, classical convolutional networks are insufficient. To overcome this problem, fully connected neural networks have been proposed (Long et al., 2015). The FCN architecture given in Figure 4 is an architecture built on CNNs. FCN accepts images created in different sizes. Convolutional layers are used instead of fully connected layers in CNN architecture. FCN architectures have downsampling and upsampling parts. In the downsampling part, high-level semantic information is extracted from the images using convolutional layers. In the upsampling section, the size of the images is equalized to the input image by deconvolution of the feature maps created in the downsampling section. This ensures that the spatial information of the original image is preserved. Finally, the segmentation output is obtained by classifying pixels from the obtained feature map. Based on the increase of upsampling, FCN architectures are divided into three types: FCN-32s, FCN-16s, and FCN-8s (Bi et al., 2018; Liu et al., 2021). In the FCN architecture, low-resolution feature maps are generated because the input is down-sampled by the convolutional layer and the pooling layer. To overcome this problem, skip connections are used in the FCN8 and FCN16 architectures. Thanks to the skip connections, high layer information and low layer information are combined to improve the pixel prediction result (Shelhamer et al., 2017).

Figure 4.
FCN Architecture (Long et al., 2015)



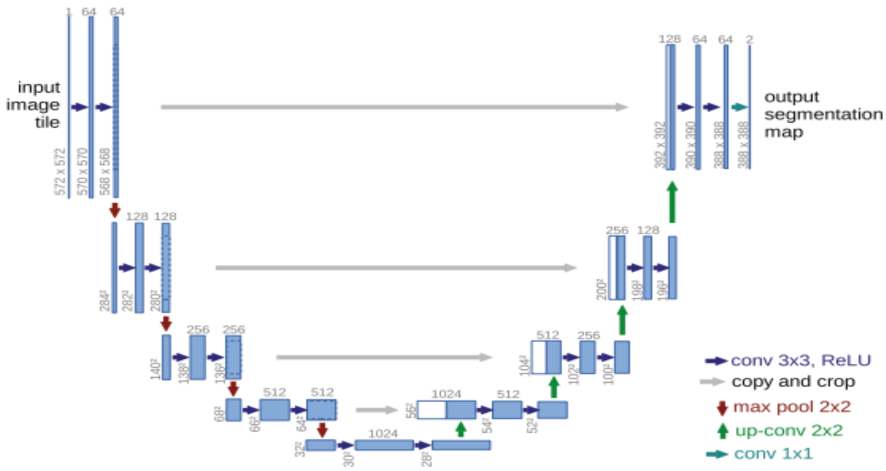
U-Net

Ronneberger et al. (2015), developed the U-Net architecture, which is a popular variation of the FCN architecture. This architecture is designed for biomedical images and achieves high accuracies with a small number of images (Sorg, 2018).

As in the FCN architecture, it has fully convolutional layers and does not include a fully connected layer. There are two parts in the U-Net architecture, where encoding and decoding operations are performed. The encoder part consists of a typical CNN. It two consecutive 3x3 convolution layers are used at each level and ReLU is applied after convolution layers. Then, the number of steps is set to 2 and the downsampling is performed with the maximum pooling method of size 2x2. With each downsampling step, the size of the image decreases and the number of feature channels doubles. In the decoder part, the number of feature channels is halved using the 2x2 upsampling process. The feature vectors extracted in the encoder part of the mesh are combined with the corresponding feature vectors in the decoder part. Two consecutive 3x3 convolution operations are applied to these combined feature maps. After each convolution operation, the ReLU is applied. In the last layer, the images are matched to the desired number of classes by 1x1 convolution and the segmentation vector is extracted. In total, the U-net architecture has 23 convolutional layers (Ronneberger et al., 2015). In Figure 5, the general structure of the U-Net architecture is given.

Figure 5

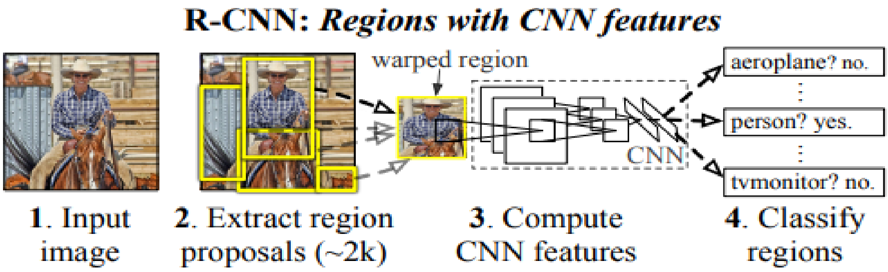
U-Net Architecture (Ronneberger et al., 2015)



Region-based Convolutional Neural Network (R-CNN)

Object recognition requires localization of objects in the image as opposed to image classification. To solve the problem of object localization in images, a region-based CNN architecture is proposed. R-CNN architecture is shown in Figure 6. With this architecture, different objects in the images are drawn with the bounding box and classification (Girshick et al., 2014). In R-CNN method, 2000 candidate regions are extracted from the image to solve the problem of selecting a large number of regions. A selective search algorithm is used in this extraction of candidate regions (Uijlings et al., 2013). Each of the 2000 candidate regions extracted from the image is given as input to the CNN architecture and feature extraction is performed. The extracted feature maps are classified using the support vector machine (SVM) algorithm. Offset values are also estimated to determine the bounding boxes of the object. However, training the 2000 CNN architecture is very time consuming (Lei et al., 2020). To overcome this situation, the Fast-R-CNN architecture has been proposed (Girshick, 2015). In Fast R-CNN architecture, the feature vector is obtained using CNN architecture. From this feature map, candidate regions are extracted. A fixed size vector is generated using the ROI pooling layer for each candidate region. These vectors serve as input to fully connected layers. Two outputs are then obtained: the class of the object and its bounding box. The fast R-CNN architecture is faster than the R-CNN architecture because it uses a single CNN architecture (Girshick, 2015).

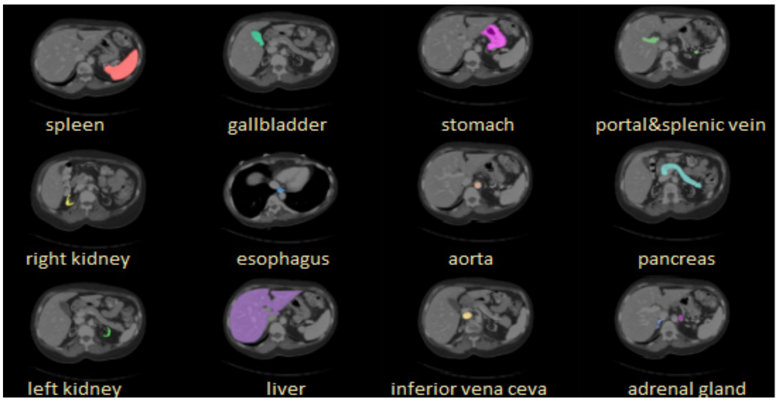
Figure 6
R-CNN Architecture (Girshick et al., 2014)



Case Study for Multi-Organ Segmentation

In this study, a computerized automatic diagnosis system was developed to assist radiologists in segmenting different organs simultaneously in abdominal computed tomography images. This study used the dataset provided by Vanderbilt University for the multiple organ segmentation competition. This dataset contains 30 images CT. The size of these images varies from 512x512x85 to 512x512x195. In addition, 13 organs are labeled in each CT image (Xu, 2015). Figure 7 shows the segmentation image of each organ. A Unet-based fusion model was proposed to perform the segmentation of these organs and this model is evaluated using the dice similarity coefficient. Before training the images of the dataset used in this study with the proposed model, their dimensions were equalized in the x, y, and z axes. image size is set to 128x128x48 and data augmentation was made by applying rotation and zooming operations to the CT images (Kayhan, 2022).

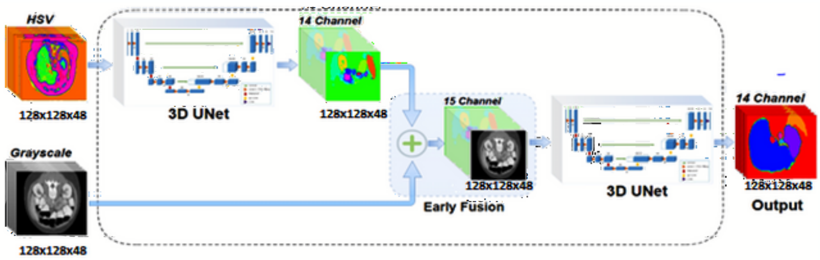
Figure 7
CT Images of Organs (Xu, 2015)



The multi-organ segmentation model proposed by Kayhan (2022) consists of two stages. In the first part, the images converted to HSV color space are trained with the 3D Unet-based model. The original images are combined with the segmentation map obtained as a result of this training, and the 3D Unet-based model in the second stage is taken as input and the predicted segmentation result is obtained. In figure 8, the general structure of the 3D U-Net based fusion model used in this study is given.

Figure 8

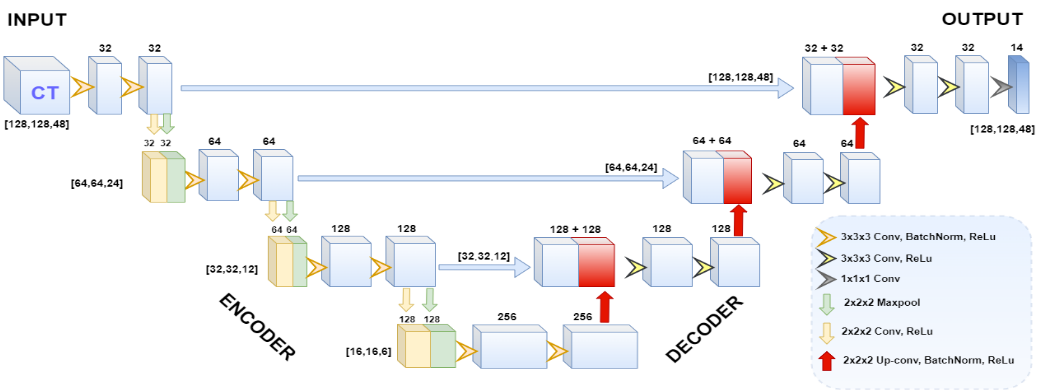
3D U-Net Based Fusion Model



In this study, the 3D U-Net model found in both stage is the same. This model has an encoder and a decoder section. In the encoder section, 3x3x3 convolution operations are performed to extract the feature map from the input image. Batch normalization and ReLU activation functions are applied to the feature maps obtained after the convolution operations. When transitioning between levels, 2x2x2 convolution with maximum pooling and 2 steps is applied. As a result of these processes, two outputs are obtained whose size is halved. The use of the maximum pooling layer is to prevent the model from remembering the features in the images and to prevent the loss of important information in the images by applying the convolution process. The outputs of these two layers are combined and used as input for the next layer. In the decoder section, the upsampling is performed until the size of the input image is reached. The feature vector extracted from each layer in the decoder section is combined with the feature vector from the encoder section. Then convolution operations are performed with a size of 3x3x3. The segmentation image is created by implementing the 1x1x1 convolution and the softmax to the feature map obtained in the last layer. The 3D U-Net based model used in this study is given in figure 9 (Kayhan, 2022).

Figure 9

3D U-Net Based Model



For the training of the 3D U-Net based model used in this study, the learning rate was set to 1e-3, the batch size to 2, and the activation function to ReLU. This model is run in 300 steps on both raw and augmented dataTable 1 shows that data augmentation improves the segmentation outcome. After training with augmented data, the average segmentation result of all organs was found to be 79.6%, and the highest accuracy result was obtained for the liver organ, and the lowest accuracy rate was obtained for the left adrenal gland. Actual segmentation and estimated segmentation images are given in figure 10 and figure 11.

Organ segmentation is of great importance in medical image analysis. In this study, a computerised system was developed to automate the segmentation process performed manually by radiologists. It has been shown that these systems can provide successful results and help radiologist.

Table 1

Segmentation Results Before and After Data Augmentation (Kayhan, 2022)

	Data Augmentation	
Organs	**False**	**True**
Spleen	0.929	0.94
Right kidney	0.918	0.934
Left kidney	0.92	0.937
Esophagus	0.704	0.698
Gallbladder	0.645	0.703
Liver	0.947	0.951
Stomach	0.766	0.847
Aorta	0.887	0.873
Inferior vena veva	0.798	0.816
Portal and splenic vein	0.638	0.698
Pancreas	0.663	0.774
Right adrenal gland	0.546	0.611
Left adrenal gland	0.517	0.558
Average	0.76	0.796

Table 2

Training and Testing Results of Augmented Data (Kayhan, 2022)

	Data Augmentation	
Organs	**Train**	**Test**
Spleen	0.951	0.94
Right kidney	0.937	0.934
Left kidney	0.939	0.937
Esophagus	0.887	0.698
Gallbladder	0.836	0.703
Liver	0.956	0.951
Stomach	0.917	0.847
Aorta	0.906	0.873
Inferior vena veva	0.879	0.816
Portal and splenic vein	0.811	0.698
Pancreas	0.841	0.774
Right adrenal gland	0.851	0.611
Left adrenal gland	0.834	0.558
Average	0.888	0.796

Figure 10

Actual Segmentation and Predicted Segmentation Images   (Kayhan, 2022)

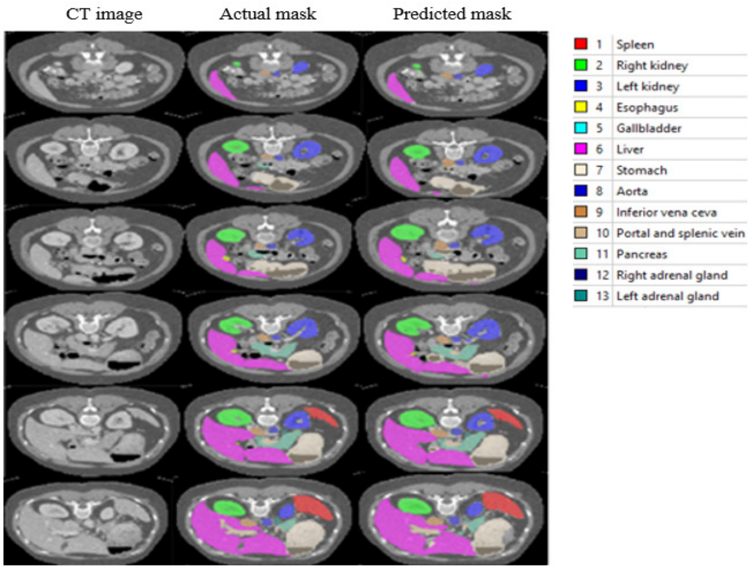
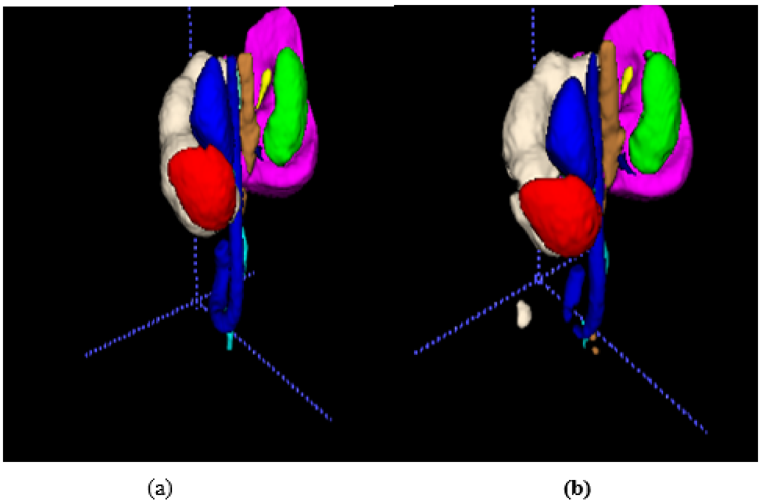


Figure 11

(a) Actual (b) Predictive 3D Segmentation Mask (Kayhan, 2022)



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Similarity Index
The similarity index obtained from the ithenticate software for this book chapter is 8%.

To Cite This Chapter:
Kayhan, B. & Uymaz, S.A. (2023). Multi Organ Segmentation in Medical Images. In S.N. Guner, Y. Uzun & I. Cetin (Eds.), *Current Studies in Healthcare and Technology* (pp.59-72). ISRES Publishing.

CHAPTER 6

Diagnosis of COVID-19 from 3D Medical Images using Deep Learning Approaches

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Diagnosis of COVID-19 from 3D Medical Images using Deep Learning Approaches

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Introduction

Coronavirus, which started in China in 2019, has affected the whole world. The widespread impact of this virus worldwide has been referred to as a pandemic and has resulted in the deaths of many people. Many countries have allocated resources for early and accurate diagnosis as well as treatment of the disease. Various methods are used for the diagnosis of the disease, including antibody tests, RT-PCR, and Computed Tomography (CT). Based on some studies, it has been observed that the accuracy rates of antibody tests and RT-PCR may not be sufficient. Among the methods used, the CT scan provides the highest accuracy. Most individuals diagnosed with COVID-19 exhibit characteristic radiographic findings on CT scans, for example ground-glass opacities, multifocal patchy consolidations (Zhu et al., 2020). However, the expertise of a radiologist is needed to interpret CT images and differentiate them from other lung diseases.

In the contemporary, artificial intelligence (AI) has been increasingly employed across diverse domains that were traditionally exclusive to experts. AI has become increasingly popular and has been prominent since Alan Turing's work in the 1950s, with various studies and approaches in AI. AI approaches are also commonly used to diagnose many diseases in the healthcare field. AI techniques such as segmentation and classification are used in the diagnosis of diseases. Various studies have been conducted using AI techniques for COVID-19 diagnosis as well. In the literature, it has been shown that using AI, it is possible to decide whether a person has COVID-19, has different lung diseases or is healthy according to their CT scan without the need for a radiologist's expertise.

The classification problem is a common type of problem encountered in many areas, including the field of healthcare. Problems such as disease classification from blood test results, disease detection from images, and various other problems can be considered classification problems. Classification is defined as determining which predefined class each item in a dataset belongs to. Machine learning (ML) is included of artificial intelligence and includes various classification methods.

Deep learning approaches can also be expressed as deep neural networks and is a subfield of ML science. Deep learning approaches are one of the classification methods under the umbrella of ml. It is essentially a system that emulates the cognitive processes of the human brain and has emerged as a successful approach for working with large-scale datasets (Singh et al., 2020). Deep learning approaches excel in self-feature extraction from data. The increasing availability of images and advancements in technology, along with the introduction of the ImageNet dataset in 2012, has contributed to the growing popularity of deep learning as a research field.

Deep learning methods consist of architectures with different characteristics for example Convolutional Neural Networks (CNNs) for images, standard Artificial Neural Networks, Recurrent Neural Networks (RNNs) commonly used in natural language processing problems, and Generative Adversarial Networks (GANs) used in areas for example generating new images. CNNs, a subfield of deep learning, are widely employed for image classification tasks. The architecture of CNNs encompasses convolution process layer, pooling process and fully connected layers. In the convolution process, the image features are extracted. The main purpose of the pooling layer added between different convolutional layers is to reduce dimensionality. In the fully connected process, the classification is performed. AlexNet, LeNet, GoogleNet, VGG-Net, ResNet, and DenseNet are some of the commonly used CNN architectures for classification and pattern recognition tasks.

Deep learning methods are able to classify images without the need for expert feature extraction, making them a valuable tool for rapid diagnosis in the medical field. Recent advancements in deep learning have enabled the development of computer vision models that can assist doctors in diagnosing various diseases. Studies in this field have shown promising results (Esteva et al., 2017; Litjens et al., 2017).

Lung X-Ray is a method that allows for quick imaging of the lungs using radiation beams passing through the front of the chest. CT, on the other hand, provides more detailed images and clearer 3D images. Compared to chest radiography and chest ultrasound, CT scans are the most popular approach for chest imaging. CT has gained popularity by providing high-resolution 3D chest scans. Figure 1 shows CT images and X-Ray. Images that need to be classified using deep learning methods can be 2D or 3D. For example, X-Ray images can be considered as 2D images, while CT images can be considered as 3D images. 2D images are single-channel images consisting of RGB (red, blue, green) channels. 3D images, on the other hand, are stacks of multi-channel images obtained sequentially. CNN architecture works similarly on 2D and 3D images. In the case of having 3D images, the convolution and pooling layers employ filters and masks with a channel count matching that of the image.

Figure 1

X-ray ve BT images (Cellina et al., 2020)

Scientific investigations conducted during the COVID-19 pandemic have demonstrated that CT scans are faster and more accurate in detecting COVID-19 lesions compared to rRT-PCR testing (Ai et al., 2020). COVID-19 findings on CT scans are associated with ground-glass opacities, which can be labor-intensive and subjective for radiologists to label. Artificial intelligence models, on the other hand, can perform these tasks quickly and reliably based on learned rules (Wang et al., 2021). There are numerous studies on lung diseases using CT scans, and these studies demonstrate that deep learning yields highly effective results in this field. (Angelini et al., 2019; Walsh et al., 2020; Wang et al., 2017). Numerous models have been proposed using deep learning approaches for COVID-19, including studies that utilize X-ray and CT scans in the literature.

Informed by relevant literature that employed CT images for COVID-19 prediction, experimental studies were conducted on a publicly available dataset using some traditional CNN architectures to aim for COVID-19 prediction. In this binary classification problem for COVID-19, classification was performed as positive or negative. Widely used CNN architectures, such as DenseNet and ResNet, were employed in the study. Results obtained with the standard settings of these architectures from the literature without any fine-tuning showed that ResNet architecture achieved good performance with an accuracy rate of 86%.

COVID-19

A noval virus called coronavirus (COVID-19) was discovered in 2019. This virus causes rapid lung involvement and lung damage, making early diagnosis and treatment crucial. The widespread of COVID-19 in many countries led to its classification as a pandemic, and most countries faced medical resource shortages. Many countries started utilizing the majority of their resources towards diagnosing this disease, preventing further spread, and finding necessary treatment methods. Therefore, early diagnosis, identification of high-risk patients, and optimization of medical resources have become of great importance.

During the pandemic, early diagnosis and high accuracy have been crucial in the fight against COVID-19. Various methods have been used for the diagnosis of the disease, including antibody tests, RT-PCR, and CT scans. Some studies in the literature reveal that antibodies and PT-PCR tests do not give the desired level of accuracy and their reliability is reduced. (Fang et al., 2020). In addition, the limited availability of test kits for performing RT-PCR tests in some countries has contributed to the spread of the pandemic and made early diagnosis more difficult. The highest accuracy in COVID-19 diagnosis has been achieved with CT scans (Xie et al., 2020; Ai et al., 2020). However, in addition to achieving high accuracy for diagnosis, the interpretation of CT scans requires evaluation by a radiology specialist in order to distinguish COVID-19 lesions from those of other lung diseases.

Deep Learning

Artificial intelligence can be defined as the imitation of human abilities by a system or machine. Nowadays, examples of artificial intelligence can be found in many fields, such as virtual assistants, intelligent disease diagnosis systems, banking applications, autonomous vehicles, etc. Machine learning, a subfield of artificial intelligence, involves machines learning from a dataset and producing appropriate outputs when encountering similar situations that are not included in the dataset.

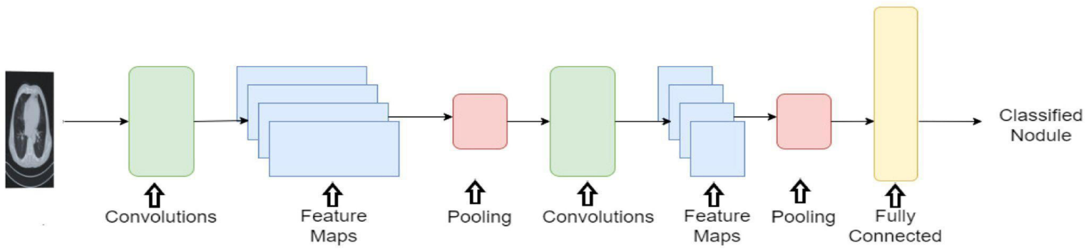
Deep learning within machine learning is a field of study that works like a human brain to process data and can process larger data sets compared to traditional machine learning methods. It allows us to train artificial intelligence to predict outputs based on a given dataset. Deep learning requires more powerful computers to handle larger datasets. Unlike feature selection in machine learning methods, where features are taught to the system due to the advantage of having fewer data, deep learning approaches should perform feature extraction processes by themselves (LeCun et al., 2015). In summary, deep learning methods do not require preprocessing steps, which sets them apart from many other machine learning methods (Li et al., 2018).

Deep learning is a widely adopted approach across various application domains, including biomedical, translators, chatbots and service robots, image enhancement and colorization, facial and voice recognition systems, object detection, object tracking, cyber threat analysis, natural language processing, recommendation systems, autonomous vehicles, virtual assistants, alarm systems, and many more.

What is CNN?

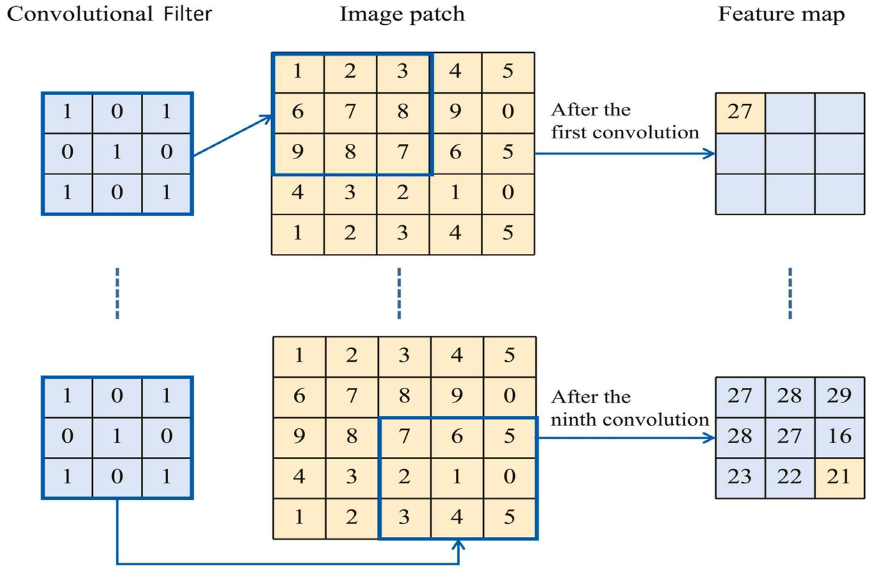
The CNN, a subfield of deep learning, is a frequently used architecture for image classification problems. CNN has layers for different functions such as convolution, pooling and fully connected. CNNs are widely employed for analyzing visual images. Due to their ability to extract features using filters on images, they are popular in image processing studies. (Modak et al., 2023). The convolutional layer performs feature extraction by running filters over the input data. The pooling layer, commonly used between convolutional layers, reduces the dimensionality of the output from the convolutional layer. Following the convolutional and pooling layers, the input data is flattened into a 1D vector and then forwarded to the fully connected layer for classification utilizing a multi-layer artificial neural network. The layers that constitute a 2D CNN architecture and the basic structure of the architecture are presented in Figure 2.

Figure 2
2D CNN architecture (Modak et al., 2023)



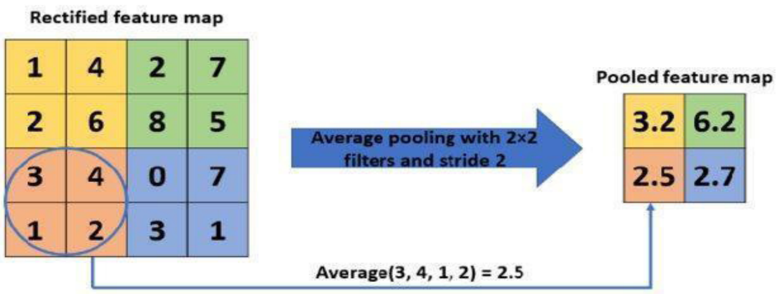
Usually, the images worked on are in the form of 2D MxN matrices. The fundamental expectation in performing convolution operation on an image is for the deep learning model to extract the features of the input image. In this layer, where features are extracted, uses filters, which are weights designed to detect the desired features. The filters move step by step over the image for feature extraction. The convolution in CNN involves convolving the image with filters, which enables the automatic extraction of features from the image. These filters' weights are updated through backpropagation during the training process of the CNN. High values are obtained in regions where the searched feature is present, while low values are obtained in regions where the searched feature is absent. The 2D convolution process is shown in Figure 3. The result matrix obtained from the filter is then subjected to an activation function before passing it to the next layer. Examples of these functions are Relu, Leaky Relu, Softmax, and tan H.

Figure 3
Convolution Layer (Gu et al., 2021)



Each convolutional layer in a CNN can have multiple filters. In this case, each filter captures different features, resulting in feature maps. Feature maps represent the features obtained from input images and include local features. Pooling layer is a down sampling layer added after the convolutional layer in a CNN, which represents a form of subsampling and reduces the dimensionality of the output feature map produced by the convolutional layer. In the deep learning phase, the size reduction method is used to reduce the computational cost. The pooling layer typically comes after the convolutional layer and serves as a connection with the fully connected layer. Max pooling and average pooling are pooling methods frequently used in the literature. Max pooling takes the maximum value within the pooled region of the input image, while average pooling takes the average of all values within the pooled region. An example is presented in Figure 4 to examine the average pooling process example.

Figure 4
Average Pooling (Gholamalinejad & Khosravi, 2020)



The data that is separated and dimensionality reduced in the convolutional and pooling layers is passed to a fully connected layer. In this layer, the classification is performed. This layer, called the fully connected layer, is the layer where the neural network structure is located. Before the fully connected layer, a flattening operation is performed on the data that has gone through the pooling process. This flattening operation converts the data into column vectors, which will be used as input to the fully connected layer. At each learning stage, backpropagation is performed, during which the weights and filters in the fully connected layer are updated, thus completing the learning process. The purpose of backpropagation is to determine important features in the input images during the learning process by propagating the error rate with labeled data.

What is 3D CNN?

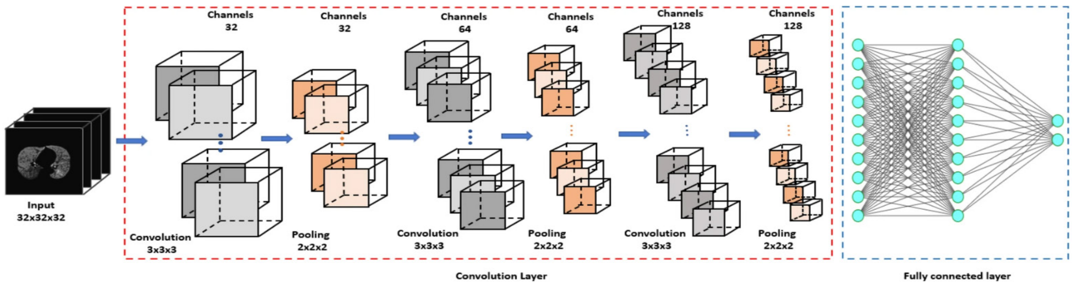
3D CNN is the CNN architecture used to 3D process data with temporal and/or motion information, such as videos, moving images, medical images, motion object detection, and activity recognition. It is an advanced version of the standard 2D CNN architecture.

With the increase in 3D datasets, deep learning studies on 3D datasets have gained momentum. 3D images can be thought of as a collection of 2D image slices or a sequence of consecutive frames in a video. If a 2D CNN is applied to a 3D image, separate predictions need to be made for each image slice, which increases the processing cost. 3D CNNs, which are based on performing convolution and pooling operations in a volumetric, are effective for processing 3D images. (Demir et al., 2023). In addition, 3D CNNs are more effective in processing 3D medical images compared to 2D CNNs. (Wang et al., 2023). The first way to process 3D images is to convert traditional 2D deep learning architectures into 3D. This way, the networks can be trained not only on images but also on the development and changes over temporal frames (Qiu et al., 2017).

3D CNNs allow the learning of local patterns and features in three-dimensional datasets, typically consisting of time, height, and width dimensions. The architecture of a 3D CNN can include different types of layers designed specifically for 3D data. The overall working mechanism of a 3D CNN architecture is presented in Figure 5 as an example.

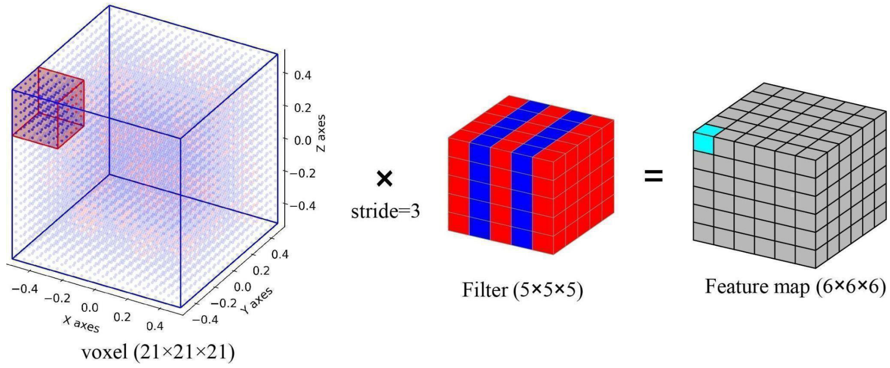
Figure 5

3D CNN architecture (Ho et al., 2021)



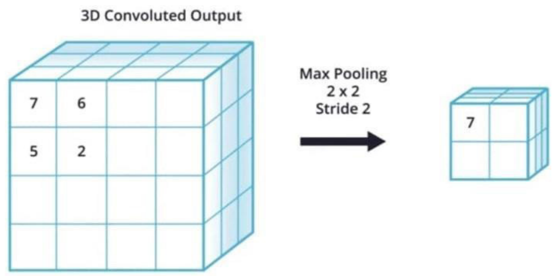
The 3D convolutional layer operates similarly to the 2D convolutional layer. However, the 3D convolutional layer differs in terms of input data structure, filter sizes, and hyperparameter numbers. The basic principle of the 3D convolutional layer is to use 3D filters to move across the data, focusing on specific regions at each step and detecting patterns in these regions to extract features. The 3D convolutional layer applies convolutional operations with a 3D filter to each pixel or voxel (3D pixel) in the input data. This filter is slid over the input data and applied to each region to extract features from that region. The 3D convolutional layer can capture 3D patterns in the input data (e.g., different structures of objects in time, depth, and width dimensions) and enable the learning of more complex features using these patterns. It is commonly used in applications that process 3D data, such as videos, medical images, and motion analytics. Figure 6 shows the 3D convolution layer.

Figure 6
3D Convolution Layer (Rao & Liu, 2020)



The pooling layer in 3D CNN architecture operates on the width, height, and depth (z-axis) dimension. Its fundamental principle is similar to the 2D pooling layer, but it is adapted for 3D data. The filters used in 3D pooling must also be 3D. In the 3D pooling process, the 3D pooling filter is applied volumetrically on the 3D image. Pooling methods, which are frequently used in 2D pooling, such as max pooling, average pooling, are also frequently used for 3d pooling. Maximum pooling selects the maximum value within the pooling region and uses that value, while average pooling takes the average of the values within the pooling region. The resulting value from the pooling process is placed at the center of the pooling region, thereby reducing the output data size. The 3D pooling operation, like in the 2D model, performs sampling and dimension reduction for the purpose of down sampling. Additionally, it reduces the computational burden of the network, resulting in faster operation. Therefore, the 3D pooling layer is an important component in 3D convolutional neural network architectures. Figure 7 shows the 3D pooling layer.

Figure 7
3D CNN Pooling Layer



In the same way as 2D CNN, After the convolutional and pooling layers, the outputs are flattened and used to generate predictions for classification, regression, or other tasks using fully connected layers. The flattened vector is then linked to the neurons. Each neuron is connected to all input data and uses weight and bias values to compute its outputs. The fully connected layer obtains the final outputs, which are then used to make predictions for classification, regression, or other tasks. The fully connected layer is located at the end of the network, producing the final outputs and enabling the model to make predictions for classification or other outputs. However, the use of fully connected layers in a 3D CNN structure can increase the complexity of the model and pose a risk of overfitting. Therefore, it is important to use properly configured and regularized fully connected layers.

Deep Learning Studies on Diagnosis of COVID-19

Many studies have been conducted in the literature on deep learning methods to assist in rapid detection and diagnosis throughout the COVID-19 pandemic. The main idea behind these studies is to classify images as COVID-19 positive or negative based on the findings in the images. In contrast to traditional X-ray approaches, since CT scans are 3-dimensional, they can provide a detailed image of the lungs. Studies using deep learning for COVID-19 classification have generally used specific classes. Some of those; healthy, normal, abnormal, other pneumonia, positive, negative, COVID, non-COVID.

In the conducted studies, it has been reported that in CT images, ground-glass opacities, patchy shadows, and diffuse ground-glass or scattered are most commonly identified indicators of COVID-19. Furthermore, the research revealed that COVID-19 infection findings may be present in CT images even if the PCR test is negative (Ai et al., 2020; Kovács et al., 2021; Xie et al., 2020).

Shan et al. proposed that demonstrating the potential of using deep learning methods for the detection of COVID-19 infections from CT scans, the segmentation process was performed in deep learning methods to predict the infection area to assist radiologists, using CT images of 300 COVID-19 patients (Shan et al., 2020).

Xuehait et al. their colleagues aimed to learn the distinguishing features of COVID-19 by using CT scans to classify it. They developed a self-supervised and transfer learning-based model for this purpose. The suggested model classifies CT scans as COVID Positive or Negative. As a part of this study, a publicly available dataset was created and published (He et al., 2020).

In another study that performed COVID-19 classification from CT images, lung regions were detected using a threshold segmentation value, followed by the classification process (Wu et al., 2020).

In a system based on the VGG-16 deep learning model, the classification process according to CT images is classified into 3 classes, namely Negative, Mild, and Severe cases. During the training of the system, lung images and clinical data were used. The output of the system was fed into a logistic regression to obtain the final prediction (Ning et al., 2020).

A multi-task self-attention learning model has been revealed for detection COVID-19 and the identification of different types of lung diseases other than COVID-19. The proposed model combines two different 3D CNN algorithms to perform different tasks (Wang et al., 2020).

In a study where the ResNet50V2 model was used as the base model to CT scans as either COVID-19 positive and negative. In this study, a feature pyramid network was applied to investigate various resolutions of input images, and it was observed that this addition significantly improved the classification performance (Rahimzadeh et al., 2021).

In another study that used a hybrid approach for COVID-19, the advantages of Transformer and CNN architectures were combined. The local feature extraction ability of CNN and the global feature extraction ability of the transformer were used together. The proposed model achieved an accuracy of 96.7%. In previous studies, using only CNN resulted in an accuracy of 95.2%, and using only the transformer resulted in an accuracy of 75.8%. Thus, it was clearly observed that the proposed hybrid model improved the accuracy performance (Fan et al., 2022).

In a study that used Fractional Fourier entropy (FrFE) for feature extraction, the deep learning method, Deep stacked sparse autoencoder (DSSAE), was used for

COVID-19 classification. The authors also used an improved data augmentation method to prevent overfitting. The performance of the proposed model was compared with different state-of-the-art models, and its COVID-19 classification accuracy was demonstrated (S.-H. Wang et al., 2021).

Various studies have been conducted on CT images using deep learning methods to distinguish between patients with and without COVID-19 (Mei et al., 2020; Zhang et al., 2020). Many of these studies classified cases into different categories, such as normal, non-COVID-19 pneumonia, or non-pneumonia during the classification stage (Song et al., 2020; S. Wang et al., 2021; Xu et al., 2020).

A U-Net with an attention mechanism was applied to CT images, which is an efficient tool for COVID-19 diagnosis, with the aim of assisting in diagnosis and patient monitoring. Experimental results evaluated on a COVID-19 segmentation dataset containing 473 CT slices showed that the proposed method could achieve accurate and fast segmentation results in COVID-19 cases (Zhou et al., 2021).

Application

An experimental study was conducted using a dataset obtained and made accessible in Moscow, for the classification of patients as COVID-19 positive or negative. The dataset consists of CT images of approximately 1100 patients from four classes. It includes CT scans of patients with COVID-19 findings, as well as scans without such findings (Morozov et al., 2020).

The experimental study followed the classification of patients into four classes based on the extent of lung involvement: Class 1 includes patients with normal lung tissue, Class 2 includes patients with 25% lung involvement, Class 3 includes patients with 25-50% lung involvement, and Class 4 includes patients with over 75% lung involvement. Inspired by previous studies in the literature, for the experimental study, Class 1 patients, who do not have COVID-19, were considered as the first class, and Class 2 patients, who have 25-50% lung involvement, were combined with Class 3 patients, who have 25% lung involvement, to represent patients with COVID-19. This way, the classification problem was transformed into a binary classification problem. The study used a subset of the downloaded dataset, which included 100 COVID-19 patients and 100 patients with normal lung images who were classified as COVID-19 negative.

A 3D CNN was used to predict COVID-19 from CT scans. The data in Nifti format was read and then subjected to normalization to prepare it for input into the CNN. Normalization was performed using a threshold of -1000 and 400, which are commonly used in the literature. The data was resized to make it suitable for input into the CNN.

70% of the data set used in the experimental study is reserved for training. Half of the remaining 30% data set is reserved for validation and the other half for testing. Experiments were conducted using 3D versions of well-known CNN architectures such as ResNet and DenseNet (He et al., 2016; Huang et al., 2017). The original versions of these architectures were used without any fine-tuning. The experiments were conducted on Colab using TPU and GPU. A batch size of 2 and a learning rate of 0.0001 were set for each model. The sigmoid activation function was used for all models, and the Binary Cross Entropy loss function was used. The selected models were trained for 50 epochs, and the results obtained after training were evaluated.

The confusion matrix is a matrix used for evaluating classification performance in classification problems. It consists of four main elements based on the true class and predicted class values: True Positives (TP), False Positives (FP), True Negatives (TN), and False Negatives (FN). Performance metrics such as accuracy, recall, specificity, precision, and F-measure can be calculated using the confusion matrix. Accuracy represents the ratio of correctly classified examples to the total number of examples.

Recall shows the proportion of true positives that are correctly classified. Specificity shows the proportion of true negatives that are correctly classified. Precision shows the proportion of positive predictions that are truly correct. F-measure provides a summary of classification performance and measures the balance between precision and recall. The formulas for the basic evaluation metrics in the confusion matrix are presented in Table 1.

Table 1

The fundamental evaluation metrics and their formulas of the confusion matrix

Measure	Formula
Accuracy	(TN+TP) / (TP+FP+TN+FN)
Precision	TP / (FP+TP)
Recall	TP / (FN+TP)
Specificity	TN / (FP+TN)
F1-score	2 * ((precision * recall) / (precision + recall))

The results of the experimental study are presented in Table 2, showing the Recall values which represent the proportion of COVID-19 positive cases that were mistakenly predicted as negative by the model. A low Recall value indicates poor performance in correctly identifying positive cases. On the other hand, Precision value focuses on whether the cases predicted as positive by the model are truly positive. Striking a balance between Recall and Precision is important in this context. The Specificity metric indicates the proportion of COVID-19 negative cases that were correctly predicted as negative by the model. Based on these results, the highest accuracy rate was achieved with ResNet18 and ResNet50 architectures, with an accuracy rate of 86%. The F-measure values, which are a comprehensive metric that incorporates all error costs, were measured as 84% and 85% respectively for ResNet18 and ResNet50 architectures. Fine-tuning of the methods and expansion of the dataset can potentially lead to performance improvements.

Table 2

Experimental Study Results

Model	Accuracy	Recall	Specificity	Precision	F- Measure
DenseNet201	0,83	0.66	1	1	0,79
DenseNet169	0,8	0,6	1	1	0,75
ResNet18	0,86	0,73	1	1	0,84
ResNet50	0,86	0,8	0,93	0,92	0,85

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To Cite This Chapter:
Uymaz, S. & Uymaz, O & Kaya, E. (2023). Diagnosis of COVID-19 from 3D Medical Images using Deep Learning Approaches. In S.N. Guner, Y. Uzun & I. Cetin (Eds.), *Current Studies in Healthcare and Technology* (pp.73–87). ISRES Publishing.

CHAPTER 7

Technological Applications in Health Promotion

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Technological Applications in Health Promotion

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Introduction

In 1986, The concept of health as a resource or asset was introduced at the First International Conference on Health Promotion. Health includes economic and social oppurtunities and resources, living and working conditions in homes and communities, medical care and personel behaviors (Figure 1) . We can change health behaviors to be healthy. The process of gaining health behaviors includes social practices as well as individuals. Health promotion is the most important focus in the provision of primary health care services in our country. Health promotion programs are established taking into account the population and possible health risk in each region. Health promotion as a concept includes some core principles (Table 1).

Figure 1
Upstream and Downstream Determinants of Health (Pender et., 2015; Braveman et.al., 2001)

Table 1

Core Princeples of Health Promotion (Pender et., 2015; Rootman et.al., 2001)

Principle	Explanation
Participation	Involve the stakeholders at all stages of the Project
Empowerment	Enable individuals and communities to take control over the personal, socio-economic,and environmental factors thar affect their health.
Holism	Consider all health components; physical,mental, social,and spiritual
Intersectoral	Ensure collaboration from all the disiplines and areas concerned.
Equity	Seek fairnessin health and social justice
Sustainability	Implement chnages that can be maintained after programs have ended.
Multiple strategies	Rely on several approaches in combination.

Individuals need to have a healthy lifestyle in order to be healthy. The acquisition of healthy lifestyle behaviors varies according to each age group and special needs. Different theories and models are used in the process of gaining health behaviors. Theories and models of health behavior to promote health behavior are Health Belief Model, Theory of Reasoned Action, Theory of Planned Behaviour, Health Promotion Model, Social Cognitive Model.

Technological applications for Healthy Lifestyle Behaviors

Health promotion is expressed as a combination of health education, prevention services (primary, secondary and tertiary) and policies aimed at protecting health (Evans et al. 2017). Improvement of health provides an increase in the level of well-being of the individual (Pender, 2015). Healthy Lifestyle Behaviors Scale II (HLBS) was developed by Walker et al in 1987 and amended in 1996 (Walker et al., 1987). This scale includes nutrition, health responsibility, physical activity, interpersonal relationship, spiritual development and stress management subscales. Turkish validity and reliability study was conducted by Bahar et al. (Bahar et al, 2008). Gaining healthy Lifestyle behaviors requires a process. In this process, technological applications help us to promote health.

Ehealth is widely used in the development of health, especially in the process of gaining health behaviors. E-health is the application of new information and communication technologies, particularly the internet, to enhance or facilitate health. Information technology is very important for health promotion practice. “ePromotion of Health”or “Health ePromotion”would come closer to describing the instrumental role of information technology in health promotion work (Lintonen, Konu, Seedhouse,2008). On the other hand, web-based interventions are more successful at affecting health behavior change when using theory (Webb, Joseph, Yardley & Michie, 2010). M-health is basically applications where mobile and wireless Technologies are used to support the achievement of health goals. M-health consists of content,context and technical features (Değerli, 2021). The mHealth services have often been used for health promotion, increasing health awareness and information access.

Nutrition

Nutrition is the use of nutrients for growth, maintenance of life and maintenance of health. Nutrition is at the forefront of human needs (Pender, 2015) In the literature, infant mortality rates are high in malnourished societies; It was determined that infant growth rate was slow and intelligence scores were low. Nutrition is affected by many factors such as the cultural characteristics of the individual, economic conditions and the society in which they live. It is among the causes of many chronic diseases and cancers (T.R. Ministry of Health Türkiye Nutrition Guide, 2019; Aykut, 2011).

The WHO's "Global Action Plan for the Control and Prevention of Non-Communicable Diseases 2013-2020" emphasizes the global significance of non-communicable diseases such as diabetes, cancer, chronic respiratory diseases, and cardiovascular disorders. One of the 9 targets set to prevent the formation of these diseases and to improve health is to reduce the dietary salt/sodium intake by 30% (WHO, 2013a; WHO, 2013b). Nutrition plays an important role in reducing the incidence of diseases. Two different artificial intelligence applications are used in the evaluation of food consumption: the use of the image of the food and the use of wearable devices (Ji et al., 2020; Lu et al., 2020; Sundaravadivel et al., 2018).

It has been determined that artificial intelligence applications in the field of nutrition have high accuracy in evaluating nutrient intake, diet planning, determining the relationship between diet and disease and obtaining anthropometric measurements. Evaluation of food consumption of the individual or society plays an important role in understanding the relationship between diet and diseases and producing solutions. With this artificial intelligence technology model, users can access the nutritional content when they enter the name and portions of the meals they consume (Figure 2) (Lee et al., 2022). With artificial intelligence technology, it also helps to eliminate limitations such as difficulty in remembering, illiteracy, lack of motivation, under- or over-declaration, and cost (Zepeda et al., 2008; Ji et al., 2020).

Figure 2

Outline of the Medipiatto System https://www.semanticscholar.org/paper/Assessing-Mediterranean-Diet-Adherence-with-the-The-Vasiloglou-Lu/07ed50aa613abcb13ef3bc385b76582f037b8477

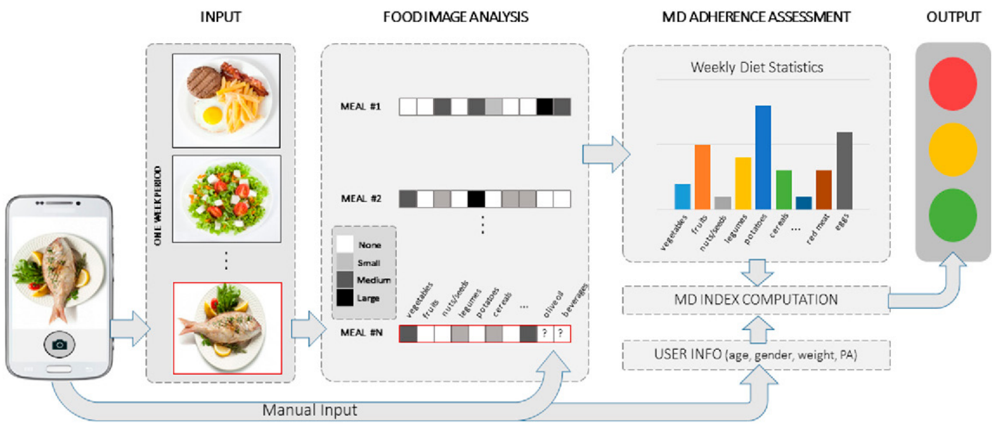


Figure 1. Outline of the medipiatto system.

Despite its limited use in the clinical setting, wearable diet monitoring tools are being developed as a new method for passively capturing food intake. The most promising wearable dietary intake sensors researched recently are sound, image and/or motion (Vu et al., 2017). Acoustic-based wearables use microphones to detect chewing and/or swallowing behavior to provide insight into the type and estimated amount of food consumed (Figure 3) (Amft and Troster, 2009; Dong et al., 2012).

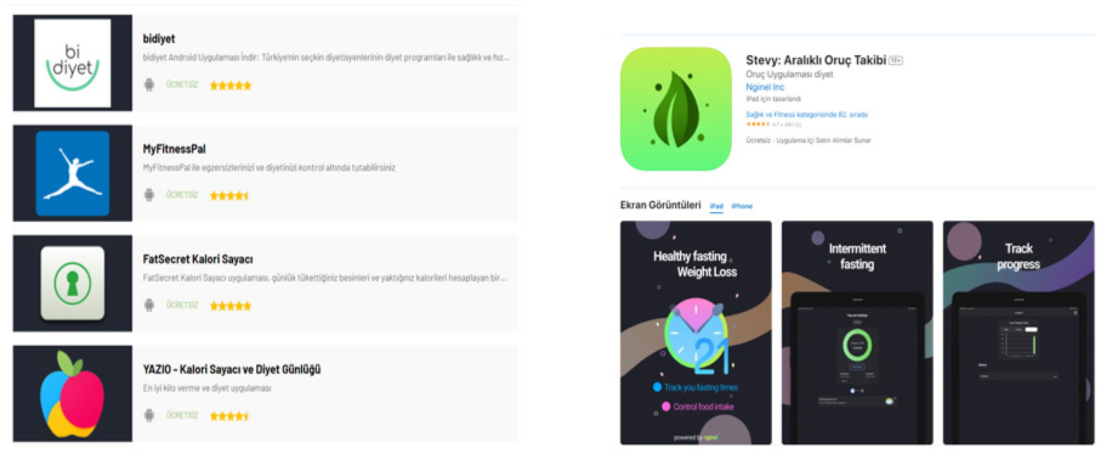
Figure 3

Wearable Devices that Assess Movement-Based Food Consumption (Dong et al., 2012).

There are many mobile phone applications on topics such as health, nutrition and weight loss. Some of these applications, which can be easily downloaded to mobile phones, are paid and some are free. These applications provide personal nutrition plan and recommendations based on the information provided by the individual (height, weight, target weight). Some of these applications include different diet models, while others serve individuals as calorie counters (Figüre 4).

Figure 4

Mobile Phone Application



There are many studies in the literature that evaluate the effectiveness of web-based applications to gain healthy eating behavior. However, the effectiveness of mobile health apps has not been adequately proven (Mckay et al., 2019; Han et al., 2018; Zhao et al., 2016). Moderately strong evidence supporting its effectiveness in modifying certain target behaviors, such as healthy food choices (6/8, 75%), number of steps (5/7, 71%) and reducing sedentary behavior (3/3, 100%) in a systematic review found (Milne-Ives et al., 2020).

Telemedicine, Telehealth and Telenutrition applications have come to the fore and started to be used in many areas, especially with the increase of social isolation and limitations in accessing health services due to the COVID-19 pandemic (Shah et al., 2021). Telenutrition is defined as the effective use of electronic information and telecommunication technologies by dietitians in the process of medical nutrition therapy with the licenses given by the relevant authorities. In this process, all steps of medical nutrition therapy such as taking anamnesis, determining the nutritional status of patients, evaluation of anthropometric, laboratory and physical findings, planning and monitoring of medical nutrition therapy can be managed by licensed dietitians (Academy of Nutrition and Dietetics, 2021). The Health Insurance Portability and Accountability Act (HIPAA) of 1996 applies to telehealth procedures in the US.

The practices approved by the American Academy of Nutrition and Dietetics for Telenutrition (HIPAA compliant Telehealth practices) are given in Table 2.

Table 2

Applications Used for Telehealth Management (Muslu, 2022)

Telehealth applications that are HIPAA compliant and approved	Skype for Business/Microsoft Teams Updox VSee Zoom for Healthcare Doxy.me Google G Suite Hangouts Meet Cisco Webex Meetings/Webex Teams Amazon Chime GoToMeeting Spruce Health Care Messenger Tabibonline.com
Telehealth applications commonly used for video conferencing	Apple FaceTime Facebook Messenger video chat Google Hangouts video WhatsApp video chat Zoom Skype

Health Responsibility

Health responsibility; It refers to the fulfillment of the duties of individuals in order to protect their physical, psychological and social well-being (Bahar et. al., 2008). According to another definition, in order to maintain the state of health, individuals should exercise, maintain weight control and perform behaviors such as staying away from smoking, and apply the doctor's recommendations by having periodic health-related examinations; Thus, individuals feel better and spend less on health. Health behaviors are affected by the sociodemographic characteristics of the individual such as age, gender, marital status, educational status, diet, as well as by the culture, income level and health policies of the society in which they live. (Pender, 2015).

Health responsibility and health promotion are two interrelated concepts. Individuals with high health responsibility strive to improve their healthFor this reason, if it is aimed to improve the health of the individual, training to increase health responsibility should be planned. Health responsibility is also emphasized in the "Multisectoral Health Responsibility Collaboration 2023" program prepared by WHO and the Ministry of Health. (Ministry of Health, 2019).

In order to increase the health responsibility of individuals, it is necessary to improve the level of health literacy. Health literacy is the ability of people to read, understand and use basic health information in line with their needsThe concept of e-health literacy has also entered the literature in order to understand the transforming health information with the developing world. (Ministry of Health, 2019; Pender, 2015). In the Strategic Plans of the Ministry of Health (2013-2017), it is aimed to improve health literacy in order to increase the responsibility of individuals on their own health. Another policy that addresses health responsibility is the Multi-Sector Health Responsibility Development Program, prepared in line with the 2020 Health Goals of the Ministry of Health and the World Health Organization. In this program, it is aimed to increase the capacity of education, infrastructure and technology so that people take more responsibility for their health. (Ministry of Health, 2019).

Analysts have calculated that as of 2013, there are more than 17,000 medical mobile apps, the vast majority of which are free to consumers. 31% of mobile phone owners and 52% of smartphone owners use their phones to search for health or medical information and 19% of smartphone owners download an app specifically to track or manage their health (Dicianno, Parmanto et al. 2015).

Telehealth applications are applications that improve the health responsibility of individuals. Telehealth applications such as MHRS (Central Physician Appointment System) and e-Nabız are among the most frequently used telehealth applications in our country. It is expected that the individual's health literacy will be developed in order to choose an outpatient clinic suitable for their symptoms with the MHRS application. Applications such as e-Nabız, individuals can follow their medical analysis, doctor’s appointments. These applications can improve the health responsibility of individuals.

Physical Activity

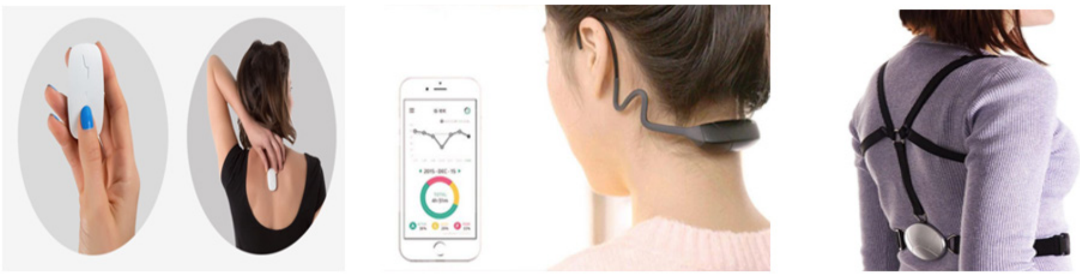
Physical activity includes all kinds of movements that require energy expenditure by using the muscles in the tempo of daily life. Exercise, on the other hand, refers to the whole of regular, programmed and repetitive physical activities aimed at maintaining or improving one or more components of physical fitness, unlike physical activity (T.R. Ministry of Health Turkish Public Health Institution, 2014). There are many studies that show that lack of physical activity is an important determinant in the emergence and prognosis of some diseases. One of the first studies on this subject was made in London in 1864. In the study, the causes of death belonging to two different occupational groups were examined and mortality rates due to coronary heart diseases were found to be higher among tailors than among farmers. The researchers attributed this result to the fact that the tailors had a more sedentary lifestyle than the farmers (MacAuley, 1994). With the developing technology, the level of physical activity has decreased to a great extent. The physical activity level of individuals is gradually decreasing due to the fact that many lines of work require sitting down and the use of technology increases. (Boyce et al., 2008). According to the Turkey Nutrition and Health Survey, the rate of men who do not exercise at all is 69.5% in the 19-30 age group and 73.2% in the 31-50 age group. While the proportion of women who do not exercise at all, similar to men, increases with age, it was determined as 76.6% in the 19-30 age group and 88% in the 75 and over age group (Hacettepe University, 2014). According to the Chronic Diseases Risk Factors Survey, in Turkey; It was determined that 87% of women and 77% of men had insufficient physical activity levels (Ünal et al., 2013). It is possible to examine the effects of physical activity on human health under two headings: physical health and mental health. Physical activity has positive effects on metabolic functions of the body, especially on the musculoskeletal system.

Most of the wearable technologies are fitness trackers, smartwatches and smart glasses. Fitness trackers, smart watches, and smart glasses generally measure heart rate, steps taken, and sleep patterns.

There are many different applications in Web 2.0 technologies in general. Some of the most used applications are Facebook, YouTube, MySpace, Linkedin, Twitter, Google, Wikipedia blog pages (Kekeç Morkoç & Erdönmez, 2015). In the process of staying at home created by the epidemic, people have turned to the internet and technology more. The increase in the duration of staying at home can lead to an inactive life and cause individuals to experience negative emotional states physically and mentally. Local governments continued to reach people by creating sports and physical activity activity programs with the Web 2.0 tools they used in this process (Atalı, Altuntaş ve Tarım, 2020).

Wearable technologies are also used in the treatment of posture disorders. With the help of the developed sensor devices, it is aimed to gain the correct posture. Finger-sized new generation devices connect to smartphones and analyze users' postures. These devices are a training wearable device worn on a person's upper or lower back to correct their posture (Figure 5).

Figure 5
Wearable Technologies for Posture (https://www.uprightpose.com/)



The use of smart watches as integrated into a phone has brought many conveniences to the users. For example; Without the need to carry the phone, adding many important information and performing transactions can be carried out with the smart watchAn individual with a smartwatch can easily have scores such as steps, number of stairs climbed, distance walked, standing hours, estimated energy expenditure (EE) and HR. You can get this information from Apple Watch, Fitbit, Samsung and Garmin etc. can be accessed through many smart watch manufacturers devices (Massoomi ve Handberg, 2019:182). In addition to smart watches, smart wristbands are often used for tracking physical activity (Figure 6).

Figure 6

Smartwatches and Smart Wristbands (https://shiftdelete.net/akilli-bileklik-vs-akilli-saat)

Interpersonal relationship

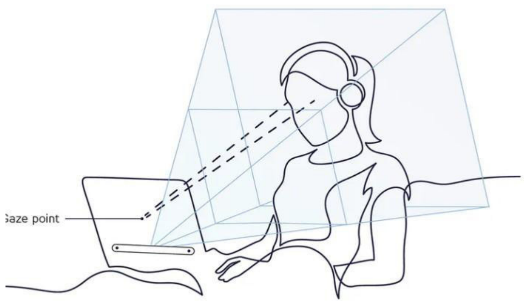
Especially during the Covid 19 Pandemic process, technological applications have been used to strengthen interpersonal relations. Facebook, whatsapp, Instagram, twitter applications create an opportunity for interpersonal communication by reminding people of their special days and providing the opportunity to see daily shares. Disadvantaged groups in the society (visually, hearing impaired and orthopedically impaired, bedridden patients, individuals from different ethnic groups, the elderly, the homeless, etc.) may experience difficulties in interpersonal relations. Interpersonal relations have an important place in reaching social resources as well as the socialization of individuals.

Eye-tracking Technology

One or more cameras, certain light sources, and processing power make up an eye tracking system. The camera stream is converted into data points by algorithms using machine learning and advanced image processing (Figure 7).

Figure 7

*Basic Principles of eye-tracking technology (*https://www.tobii.com/learn-and-support/get-started/what-is-eye-tracking)

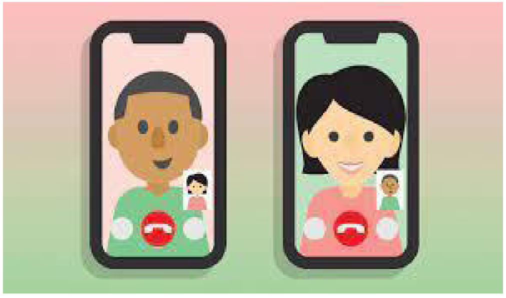


Video Calling

Video calling is an important tool for mutual communication from long distances.

Figure 8

Video calling (By David,Lynch, https://www.payetteforward.com/what-is-video-calling-how-to-make-video-calls-on-iphone-android/)



Spiritual Development

Spirituality is a medium through which people seek information to life's challenges, establish their own individuality, find meaning and significance, and know the difference between right and wrong. Spirituality, in this aspect, can be very personalized and can assist in the development of a person's belief structure. Smartphones, meditation, mindfulness mobile applications are commonly used in the development of spiritual health.

Stress Management

Stress is one of the main causes of many diseases. In order to be successful in stress management, it is necessary to focus on approaches to stress management.

Appoaches to stress management;

1. Interventions to minimize the frequency of stress-inducing situations
2. Interventions to increase resistance to stress

Technological devices are very important in stress management. Such as;

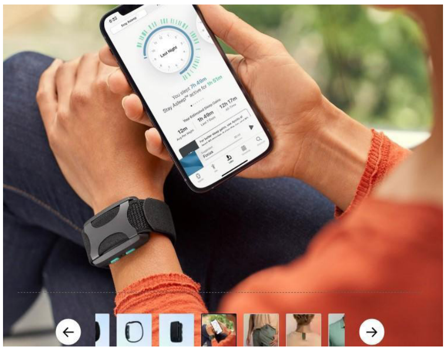
1. **Stress Sensor Patch** : Patch tapes showing the release of contisol in the body during stress have been produced (Büyükgöze, 2019). It helps people to evaluate their stress sittuations and manage stress.
2. **Time Planners:** Time reminder clocks and mobile applications are available to help with time planning in stress management.There are embossed and talking clocks for visually impaired students and vibrating clocks for hearing impaired students.
3. **Touch Therapy (Apollo Wearable) :** Therapeutic touch is a holistic therapy that

   promotes healling and reduce pain and anxiety. The Apolla device does this with

   vibrational pads (Grantham, 2022).

Figure 9

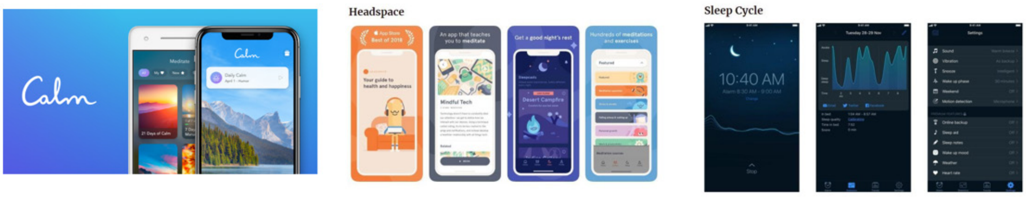
Apolla Wearable (APOLLO 2023 https://apolloneuro.com/products/apollo-wearable)



4. **Meditation Applications**
5. **Yoga Applications**
6. **Healthy sleep applications :** A healthy sleep has an important place in the process of coping with stress. Some applications make it easier to fall asleep (Calm etc.) some applications incude sleep training (Headspace etc.),and some applications; It allows monitoring sleep process (Sleep cycle etc)

Figure 10

Some examples of Healthy Sleep Applications (https://listelist.com/uyku-uygulamalari)



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Similarity Index
The similarity index obtained from the plagiarism software for this book chapter is 17 %.

To Cite This Chapter:
Mert, K. & Gurkan, K.P. (2023). Technological applications in Health Promotion. In S.N. Guner, Y. Uzun & I. Cetin (Eds.), *Current Studies in Healthcare and Technology* (Eds.), (pp.88-101). ISRES Publishing.

CHAPTER 8

Use of Technology in Surgical Nursing

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Use of Technology in Surgical Nursing

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Introduction

Nursing is an applied health discipline that deals with the health status of the individual, family, and society, which has managed to renew itself with social, cultural, and technological changes from the past to the present. Surgical Nursing, on the other hand, is a branch of nursing in which nursing activities based on scientific knowledge are coordinated, and personalized care is applied by determining the physical, psychological, and social needs of the patient to regain and maintain the patient's health and well-being.

It is known that surgery, which started in the cave period with the existence of human history, has shown static and rapid developments from time to time (Arpag et al., 2022). Today, advances in health sciences have necessitated the development of health professionals, and physicians, nurses, and other health professionals have tried to maintain their development by resorting to various ways to keep up with the development of the age (Eti Aslan, 2009).

In the dictionary of the Turkish Language Association, technology is defined as "application knowledge, application science, which covers the production methods related to an industry branch, the tools, equipment, and instruments used, and the ways of using them" and "all of the tools and equipment developed by human beings to control and change their material environment and the information related to them" (TDK Dictionary). Today, the use of technology has entered all areas of life, and it has become a necessity rather than a privilege for people to benefit from technology (Şentürk Erenel et al., 2011). In recent years, the increase in technological developments in health systems has contributed to improvements in diagnosis, treatment, and care in hospitals (Price, 2013; Bagherian et al., 2017). Some researchers believe that technology can facilitate and improve nursing care. According to these researchers, technology provides benefits such as increasing the safety of care provided to patients, reducing the workload of nurses, spending more time with their patients, alleviating their anxiety, and relieving their concerns (Price, 2013, Tunlind et al., 2015). The World Health Organization (WHO) defines technology used in health services as the use of skills and organized information developed by methods, systems, medicines, vaccines, and devices that improve the quality of life and are developed to solve health problems (WHO, Health technology assessment).

The historical development of surgery is considered in three periods, and the first period starts with the first injured person and is limited to wound care. The second period started in the mid-19th century and developed rapidly with the discovery of anesthesia, asepsis, and disinfection procedures. The third period is considered a period that has reached from the 1960s to the present day, starting with endoscopic surgical interventions and leaving its place towards robotic surgical interventions using high-level technological facilities (Arpag et al., 2022). Technology has continuously influenced and shaped nursing practices from the past to the present. As a result, technological developments reflected in the surgical field have gained momentum. This situation causes surgical nurses to work with continuously more complex machinery and equipment, and their roles and responsibilities to differentiate and increase. The introduction of technology into the surgical field through robotic surgery, artificial intelligence-based/supported applications, virtual reality applications, information systems, and similar means is largely beyond the control of the nursing discipline. Although this phenomenon does not alleviate nurses' care responsibilities towards the patient and their obligations to fulfill other differentiated duties in the team, surgical nurses are expected to always make the right decisions regarding their areas of responsibility and roles. For this, they need to understand technology and have up-to-date and comprehensive knowledge about technological developments and applications. Nurses must first have a positive perception to understand technology. Many factors such as the nurse's age, level of education, interest, and experience in technology, and whether they are open to innovation shape their current perceptions. In general, it can be said that nurses have a positive attitude toward technology and try to adapt to technological developments (Barnard & Gerber, 1999; Huang & Lee, 2011; Cakir Umar et al., 2016; Konukbay et al., 2020).

In addition to the safety risks of surgery, patient-related changes and complications can develop very rapidly in the perioperative period. Operating rooms and surgical clinics are challenging environments where ensuring patient safety is complex. The nurse's focus on the technological environment and applications can sometimes jeopardize patient safety, and technology, which is one of the risk factors related to patient safety in this challenging environment, can also be a tool to reduce this risk. In this part of our book, methods of using technology in surgical nursing will be examined under different headings.

Technological approaches in surgical nursing

It is possible to benefit from technological applications in coping with the complexity of the perioperative environment and in planning and implementing nursing care. For example, the documentation of patient information to be used in patient identification, treatment, and care planning can be done reliably and quickly with appropriate software. Physicians, nurses, dieticians, and other health professionals can save time by using a common documentation program and can obtain much more information about the patient beyond their efforts. In this way, more time and effort is saved to obtain previously questioned information. Unnecessary contact with the patient with the risk of contamination of surgical incisions is avoided, and patient delivery and evaluation are reliable and fast with the documentation system. Moreover, with artificial intelligence-supported software, patient data can be analyzed together with the information pool compiled from a large number of patients and used in patient/staff decision support systems. Data that the nurse overlooks or has difficulty associating can be analyzed with AI-supported systems, and care recommendations or checklists can be created (Jacques & Minear, 2008).

The presence and intensity of advanced technological applications such as robotic surgery, endoscopic surgery, and simulation put operating room nursing ahead of the technological development trend. In this context, knowing the perception of nurses about whether robotic nurses and artificial intelligence applications can replace nurses can give an idea about the adaptation of surgical nurses to technology. In a study conducted with operating room nurses, the knowledge level about robotic nurses and artificial intelligence was found to be medium level, and it was concluded that training on the use of technology will reduce the level of anxiety in nurses and contribute to the increase in the quality of care (Ergin et al. 2023).

Continuous technological development will continue to be a part of the healthcare system in any case. Artificial intelligence and robotic applications are increasingly involved in the perioperative process. In particular, artificial intelligence technology may lead to a redefinition of the roles of nurses along with other healthcare professionals, unlike previous development processes. Although it seems unlikely for the near future that robots will replace human nurses and provide care with empathic and emotional aspects, it is a crucial issue whether nurses will be able to keep up with technological change with the concern of losing their roles to robots. Perioperative nurses can be passive members of the changing healthcare system or a shaper of the new working order. The nurse can strengthen the bond that technology weakens between the health professional and the patient with her continuous relationship with the patient. To remain an effective component of the system, the nursing discipline should start planning today (Francis & Winfield, 2006; Needleman, 2013; Duff, 2020). Technological developments in the field of health do not push nurses out of the system but only require the definition of different roles and jobs (Kartal & Yazici, 2017). The number of studies investigating the emotions created by the use of technology in nurses is strikingly low. According to a limited number of studies, the use of information technology in the work environment can lead to both positive and negative emotions (Cakir Umar et al., 2016; Konukbay et al., 2020; Golay et al., 2022-a; Golay et al., 2022-b).

Wearable Technology

The wishes of individuals and the developing and changing trends in health services have made it necessary to collect more data on the health status of individuals. Some of these data include the individual's habits, hospitalization and departure times, medication usage hours, previous disease history and diagnostic tests, diagnosed diseases, individual measurement applications, diet, number of steps per day, anxiety level, body weight, blood glucose level, body temperature, blood pressure, pulse/respiratory rate, and oxygen saturation. Wearable technologies include tools that can be a precursor to collecting these desired data. Thanks to wearable technologies, patients/individuals can obtain information about their general health status without going to a health institution (Demirci, 2018; Dursun & Yilmaz, 2021). Wearable devices are electronic special monitoring tools synchronized to a smartphone or computer to provide wireless and long-term data tracking, they have storage areas, and data can be input and output at any time (Demirci, 2018). Wearable technology products are defined as all electronic devices (jewelry such as watches, wristbands, glasses, lenses, e-textiles, smart fabrics, headbands, rings, and hearing aids) that can be glued to the body, placed in clothes or accessories, and carried. These wearable devices can perform many tasks that computers and smart cell phones can do (Demirci, 2018; Dursun & Yilmaz, 2021).In surgery, WT is utilized in many different surgical fields for the diagnosis of diseases, postoperative evaluation, and follow-up of patients. In addition, this technology is also used in comparing different applications, measuring physical activity, and as a part of surgical training. WT is also utilized in the operating room in line with the needs of surgeons and nurses working in a sterile environment (Dursun & Yilmaz, 2021).

Measurement of physical activity in patients after surgery is an example of the use of wearable technologies in surgical patients. A decrease in physical activity is often observed in cancer patients after surgery. This leads to poor postoperative outcomes and early recurrence of cancer (Dursun & Yılmaz, 2021). In a study conducted on gastric cancer surgery patients, it was reported that wearable devices and cell phone applications were useful in objectively assessing physical activity in postoperative patients (Wu et al., 2019).Wearable technologies are used in surgery not only after surgery but also in the preoperative period (Dursun & Yilmaz, 2021). In the study of Hedrick et al. (2020), the patients were educated about the use of wearable activity monitoring devices, they were told to wear the device for 30 days before the surgery, and the step counts of the patients were recorded with the wearable devices. As a result of the study, the data recorded on the devices were examined, and it was observed that a significant decrease in the rate of postoperative complications was achieved in patients who mobilized more by following the given program.

Telesurgical nursing

In tele-nursing, communication between the patient and the nurse is provided by using telephone, computer, and interactive television (Ay, 2008). Tele-surgical nursing is the provision of preoperative and postoperative surgical preparation and care of surgical patients with telecommunication tools (Akyolcu, 2017). In surgery, telenursing practices can be carried out by telephone and video conferencing before and after surgery and after the patient is discharged to enable patients to cope with physiological, psychological, and sociocultural problems that may develop before and after surgery, to support early recovery and to improve quality of life (Ozkan & Salik Asar, 2022). Studies have shown that remote surgical care applications provide a reduction in health costs (Rowell et al., 2014), reduce perioperative mortality and morbidity rates (Barnason et al., 2009), and telecommunication services used in the preoperative process help to reduce patients' food, transportation, and hotel costs (Leshera & Shah, 2018), however, it has been observed that there are problems in telesurgical nursing practices in our country since patients live in rural areas, care is provided to elderly patients and patients' inability to use technological devices, and not enough studies have been conducted (Ozkan & Salik Asar, 2022).

Virtual Reality

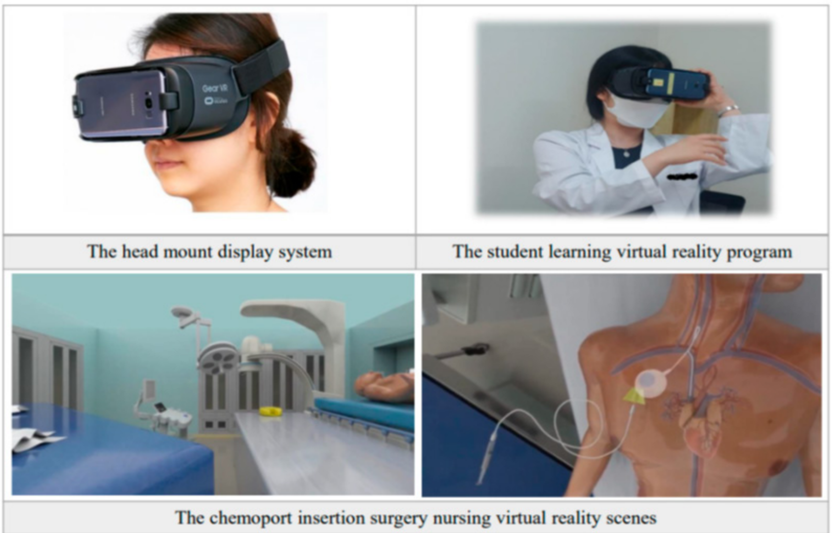
Virtual reality (VR) is the projection of computer-animated three-dimensional images to people as a "real world" with the help of some devices. These devices that enable the experience of virtual reality are a combination of a computer, glasses, headphones, and motion sensors (Dayan & Ince, 2021). Virtual reality technologies are used in healthcare services in many areas, such as surgery, to relieve symptoms by offering the opportunity to create therapeutic environments in the evaluation, diagnosis, and treatment of health problems, in the rehabilitation of patients and exercise applications, and the training of professional groups in medicine and healthcare (Yılmaz, 2021).

If we look at its use in surgical nursing, it is often seen that it is used in applications such as relieving preoperative anxiety, relieving postoperative pain, and relieving pain during wound/burn dressing. Results show that preoperative preparation using virtual reality goggles and postoperative video watching are effective on anxiety and parental satisfaction and a useful method to reduce postoperative pain in children who will undergo surgery (Turgut, 2021). Similarly, it was determined that virtual reality application before total knee replacement surgery reduced pain, anxiety and had a positive effect on vital signs (Gunes, 2021). It has been reported that the use of VR in relieving the pain observed in patients with dressing changes during burn care (Guo et al., 2014) and anxiety levels decreased with the use of VR goggles, and patients felt more comfortable (Kipping et al., 2012; Scapin et al., 2018). In a systematic review and meta-analysis study examining the effects of virtual reality in reducing postoperative pain, eight randomized controlled studies were examined, and it was observed that patients who received virtual reality experienced lower levels of postoperative pain than patients receiving routine care (Ding et al., 2020).

Use of technology in surgical nursing education

Nursing education includes the process of learning intensive and diverse theoretical knowledge. This information is mainly aimed at improving the student's patient care and problem-solving skills. The higher the quality of nursing education, the higher the quality of patient care (Sherwood & Drenkard, 2007). To improve the quality of education, theoretical knowledge should be used in the clinic. Students should be provided with sufficient opportunities to do this. However, nursing students have limited time in the clinic. This limitation leads to a gap between theory and practice. The use of technology contributes to filling this gap between theory and practice. With the use of technology in nursing education, the clinical environment can be simulated for students. In this way, it has been proven that the quality of nursing education increases (Cant & Cooper, 2010; Yuan et al., 2012). Similarly, virtual reality application, which allows interaction with the course subject in a virtual environment, contributes positively to the professional education of students. For example, as represented in Figure 1, interactive learning of the operating room environment and procedures can be provided for operating rooms where student access and stay time are limited (Jung & Park, 2022).

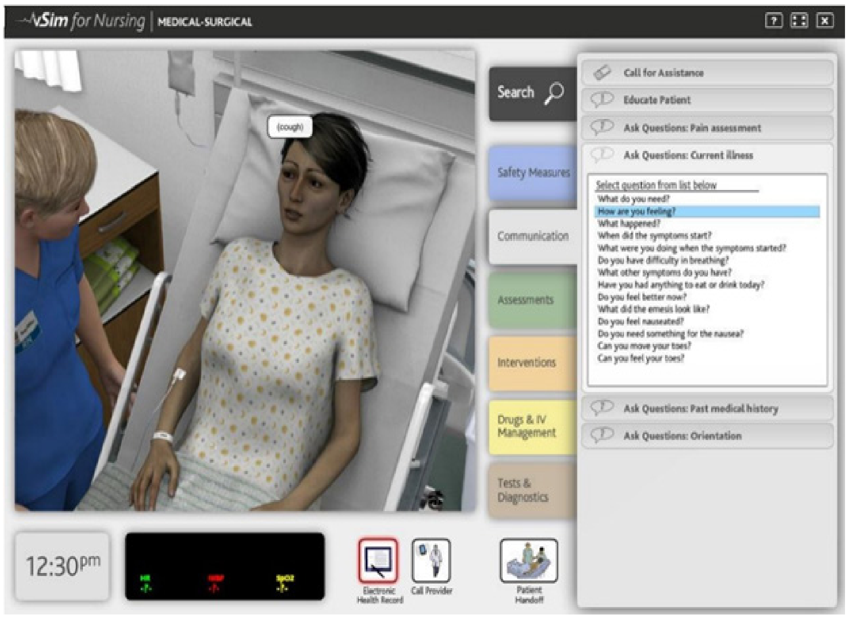
Figure 1
The virtual reality based nursing education



With the use of technology in nursing education, students can be better prepared for clinical practice. In the clinic, they can make numerous applications in educational subjects where risks related to the patient are in question, and they can see the detailed evaluation of their actions. In addition, in today's conditions, nurses work with technological devices and take responsibility for technological applications. Therefore, it has become an inevitable necessity for nursing students to benefit from technology at the highest level in their learning. Computerized simulation applications, online and offline distance education methods, virtual reality, augmented reality, and artificial intelligence are used in nursing education today. The use of technology in education is not only effective but also fun for students. The achievements show that these technologies will penetrate education even more over time (Ulupinar & Toygar, 2020). A study conducted in Turkey revealed that about a quarter of the publications in the field of nursing and technology were on nursing education. According to this research, the number of studies conducted tends to increase over the years. This increase shows the constructive effort to integrate technology into nursing education. In addition, it can be concluded that nurses have the potential to produce technology for nursing care (Aytur & Kantek, 2020).

vSim® (Figure 2), which aims to improve clinical nursing practice and patient care skills, improves students' reasoning skills (Foronda, 2015). Contrary to the examples given in this section, rare findings are showing that the use of technology does not make a positive difference in education. Various variables such as students' learning styles, approaches to technology, access opportunities, and instructors' attitudes may be determinants in the effect of technology use on education (Johnston et al., 2010). Academic nurses who train the nurses of the future should reflect on technological developments in education and pay attention to students' utilization of technology (Sendir et al., 2019).

Figure 2
vSim® for nursing



Robotic surgery and nursing

Robotic surgery is the performance of surgical procedures using robotic arms with various functions. It is one of the fastest-developing fields in medicine (Maza & Sharma, 2020). Since the 1980s, minimally invasive surgery has become widespread due to its various advantages. Laparoscopic surgery promised less pain, shorter hospital stays, fewer complications, and lower costs compared to open surgery. However, laparoscopic surgery also had its limitations. Robotic surgery has overcome these limitations of laparoscopic surgery and offered a more successful surgical process. While moving from laparoscopic surgery to robotic surgery, the da Vinci® robotic system, which is perhaps the most well-known and consists of 3 components, was developed by utilizing previous experiences (Fig.3, Fig.4, Fig.5). The da Vinci® surgical system, the first version of which was used in 1999, can now be used in dozens of different surgeries ranging from cardiac surgery to colorectal and bariatric surgery (Pugin et al., 2011).

Robotic surgical platforms have developed technologically over time. This ongoing development takes the surgical technique one step further and eliminates the need for the surgeon's physical presence in the operating room. In 2001, the first transatlantic surgical operation was performed between the USA and France (Diana & Marescaux, 2015).

Figure 3
The surgeon console of the da Vinci Si® robot

Figure 4
The da Vinci Si® imaging system

Figure 5. *Articulating arms of the da Vinci Si® robotic surgery system (The robot)*

One of the most striking effects of technological development on the surgical field is undoubtedly the introduction of robotic arms. The minimization of invasive interventions by robotic surgery provides various advantages ranging from shorter clinical hospitalization to reduced surgical complications and faster recovery. The use of this technology is becoming more and more popular for both patients and surgeons, offering ergonomics for the surgeon and technical possibilities that increase the success of surgery (Lanfranco et al., 2004; Moawad, 2020).

For robotic surgery to be successful, the entire surgical team, including the nurse, should have knowledge, skills, and active participation in this field. However, it is known that the knowledge and training of nurses in robotic surgery are insufficient. There should be certified training programs for nurses covering the aims, advantages, and disadvantages of robotic surgery and nursing care (Konateke & Güner, 2022). In a study, the rate of nurses who declared that they had sufficient knowledge about robotic surgery was found to be 34.6%. The same study showed that the main source of information about robotic surgery was the Internet (Okgün Alcan et al., 2019). In a similar study conducted with nursing students, the rate of those who declared that their knowledge about robotic surgery was partially sufficient was 73%, and the rate of those who declared that they obtained the information from the Internet was 77.8% (Oztepe Yesilyurt & Ozsoy Durmaz, 2023). In a study conducted with nurses with robotic surgery experience, it was found that there were concerns about the risks that may develop in patient safety due to robotic system failure and unexpected problems (Kang et al., 2016). It may be possible to increase the level of qualified knowledge on robotic surgery and nursing, integrate this information into the formal education curriculum, and thus reduce the various concerns of nurses about the subject.

In robotic surgery, the nurse should focus on the patient, not the technological environment and the robot. Patient safety and behavioral and physiological responses should be prioritized. Preoperative and postoperative patient needs and care in robotic surgery are similar to those in the classical method. In the preoperative period, the nurse should additionally inform the patient about how robotic surgery is performed and deal with their concerns and fears. However, especially intraoperative care differs. In the intraoperative period, the nurse takes responsibility for preparing the robotic arms, giving the patient the appropriate surgical position for the arms, and preventing contamination associated with these instruments. In addition, according to unit protocols, nurses may also take responsibility for the control of robotic arms in the preoperative period and operating room preparation (Raheem et al., 2017, Redondo-Sáenz et al., 2023). As a result, the nurse has a critical role in the preparation of the robotic surgical system and other necessary surgical equipment before and during surgery. In addition to scrubbing and circulating nurses for the operating room, the definition of a robotic surgery nurse has started to be made (Okgun Alcan et al., 2019; Martins et al., 2019). The duties, authorities, and responsibilities of robotic surgery nurses can be determined by regulations and necessary arrangements can be provided.

The Association of Perioperative Registered Nurses (AORN) draws particular attention to complications and patient safety concerning robotic surgery. Failure to adjust the patient's position on the operating table according to the robotic arms may increase the risk of physical trauma and falls. interventions to prevent nerve damage in the operating room are recommended. In addition, the use of a second surgical safety checklist is recommended for robotic surgeries lasting longer than 3-4 hours (Song et al., 2013; KilicAkman et al., 2022).

Conclusion

In professional nursing care practices, it is necessary to develop these technological tools and include them in the implementation process in health promotion and maintenance. However, shifting the focus from the patient to technological applications may increase the risks related to patient safety. The fact that different technological devices in the surgical field are not compatible and integrated, whereas most of them need to be used together at the same time, may create a complex and risky treatment environment for the patient. Although the cost of high-end technological applications such as robotic surgery is relatively high and accessibility is low, it is still a new technology. More evidentiary research is needed to demonstrate its clinical advantages and superiorities, disadvantages, and weaknesses. All technological advances should provide everyone involved in the care of individuals with the opportunity to continuously monitor and record the individual's findings. Thus, it will be possible to reduce morbidity and mortality in patients and improve their quality of life.

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Similarity Index
The similarity index obtained from the plagiarism software for this book chapter is 8%.

To Cite This Chapter:
Simsek Yaban, Z. & Cetin, I. (2023). Use of Technology in Surgical Nursing. In S.N. Guner, Y. Uzun & I. Cetin (Eds.), *Current Studies in Healthcare and Technology* (pp. 102–115). ISRES Publishing.

CHAPTER 9

Telehealth and its Place in Primary Care

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Telehealth and its Place in Primary Care

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Necmettin Erbakan University

Introduction

With the increasing world population, the need for health services has also increased. Along with advancing technologies, the scope of health services provided has become wider. It has become imperative to use scientific and technological opportunities to meet this broadening scope of supply and demand and to provide higher quality health services (Önal & Kaya, 2020). Telehealth refers to the use of information and communication technologies for health. The World Health Organization (WHO) stated that although it has been applied in the past, its use has increased significantly and has become more popular with the COVID-19 pandemic. (WHO, 2021). The first use of telehealth services started with the use of store-and-forward applications where information is stored and transmitted for diagnosis and second opinion. Today, real-time conversations can be held between the patient and the healthcare provider with interactive video calls, and patients can be monitored with wearable equipment. The scope of the services provided has expanded with these developments, and a wide range of services can now be provided from emergency intervention to chronic disease management, preventive services, and rehabilitation (Moore et al., 2017).

The use of telehealth services in primary care provides an opportunity to increase access to health services (Hickson et al., 2015). In addition to facilitating access, telehealth services increase the quality of the service provided, decrease costs, promotes health information and quality of life in patients, improve physician-patient relationships, and prevent time losses caused by commutes for both physicians and patients (Moore et al., 2017). This chapter examines the concept of telehealth and its use in primary health care.

The Concept of Telehealth

Telehealth can be summarized as remote health. WHO defines telehealth as "the use of information and communication technologies in the exchange of information, research, and evaluation necessary for the diagnosis, treatment, and prevention of disease and injury by all health professionals in health care services where distance is a critical factor, and in the continuing education of health care providers as they work to improve the health of individuals and their communities" (WHO, 2016).

According to the American Telemedicine Association (ATA), telehealth is "management and delivery systems in health and care that use technology to increase capacity and access" (ATA, 2020). In the United States of America (USA), The Center for Connected Health Policy (CCHP) defines telehealth as "a method that enables the delivery and improvement of health care, public health, and health education services using information and communication technologies" (CCHP, 2023).

Telehealth and telemedicine are often used interchangeably, but telehealth refers to a broader scope of services that cover telemedicine. Telemedicine refers specifically to remote clinical services, while telehealth refers to remote nonclinical services, such as patient education, administrative meetings, and continuous medical education, in addition to clinical services (CCHP, 2023).

Key Components of Telehealth

Live Video Conferencing

It is the most widely used form of telehealth service. This practice is also called real-time. It refers to live and two-way communication between the healthcare provider and the patient (ATA, 2020). The video link can be established between a patient and a physician, or between a physician and a specialist for consultation purposes (Olson & Thomas, 2017).

Live video interviews were conducted using audiovisual technologies. Surrounding camera systems, videoscopes and webcams can be used in the interviews. Video calls can be made through a computer monitor, plasma television, projector, or tablet. With live video calls, patients with limited mobility, patients who have geographical difficulties in accessing health services, and patients who do not want to or do not have the opportunity to come to psychiatric interviews in person can receive health services at home. Physicians can seek support from specialists located elsewhere. Health professionals can conduct training programs with participants in different locations. Patients can use these technologies to receive disease management or other important health information (CCHP, 2023).

Store-and-Forward (Asynchronous)

In telehealth services, store-and-forward refers to situations where the interaction is not done simultaneously. It is used when live video or face-to-face interaction is not required. Medical information such as digital images, documents, and prerecorded videos are stored and electronically transmitted to an advanced health center or reporting center for later evaluation (Olson & Thomas, 2017; ATA, 2020; CCHP, 2023). This method is used to aid in diagnosis and consultation between medical professionals. The health professionals and the patient do not need to be present at the same time. This increases the efficiency of health services as it allows health professionals to assess the patient at a time convenient for them (CCHP, 2023). With these technologies, store-and-forward systems are most commonly used in radiology, pathology, dermatology, and ophthalmology. In radiology, X-rays and MRIs can be transmitted to specialists. In dermatology, primary care providers can take photographs of patients' skin conditions and forward them to the dermatologist. In ophthalmology, eye scans for diabetic retinopathy, a disease that is a major cause of blindness among people with diabetes, can be digitally recorded by retinal cameras and transmitted to a specialist for review (CCHP, 2023).

Remote Monitoring

Remote monitoring is the transfer of health data, usually collected from the patient at home through sensors and monitoring equipment, to an external monitoring center. Remote monitoring is an increasingly important area of telehealth (CCHP, 2023). A wide range of health data, such as blood pressure, blood sugar, oxygen saturation, pulse, body temperature, and body weight, can be collected by remote monitoring programs (CCHP, 2020). It allows patients to be followed-up after discharge, reducing the rate of readmission to the hospital. The quality of life of elderly and disabled individuals can be improved through monitoring programs (CCHP, 2023).

Mobile Health

Mobile health is defined as the use of devices that can connect to the wireless internet, such as remote monitoring devices, personal digital assistants, and cell phones in the provision of health services. Telephone hotlines, reminder text messages, and accessing electronic patient data via mobile phones are examples of mobile health applications (WHO, 2016). Healthcare is usually delivered through an application downloaded to mobile devices. Sending messages to people to promote health behaviors and the e-pulse application used in Turkey can be given as examples of mobile health (CCHP, 2023; Republic of Turkey Ministry of Health, 2020b).

History Of Telehealth

The use of digital technologies in healthcare began in the 1950s when two hospitals in the USA succeeded in sharing X-ray images with each other over telephone lines (Rivera-Ruiz et al. 2008). With the decision taken at the 58th World Health Assembly in 2005, WHO urged member states to plan appropriate telehealth practices in their countries (58th World Health Assembly, 2005). In the same year, the Global Observatory for e-Health (GOe) was launched, whose aim is to monitor the development of telehealth applications in countries and their impact on health. In 2016, mobile health was officially defined by the WHO, and it was stated that mobile health increases access to health services and information and promotes disease self-management (Executive Board 132nd Session). At the World Health Assembly in 2018, it was stated that the use of digital technologies contributes to achieving sustainable development goals and their use should be prioritized (71st World Health Assembly, 2018).

Developments and innovations in the field of telehealth around the world have continued at an increasing pace, and the COVID-19 pandemic further increased the importance of telehealth. The restrictions during the pandemic, such as social distancing and the desire to keep people away from high-risk environments, such as hospitals, transformed telehealth practices into an urgent necessity rather than a potential opportunity (Whitelaw et al, 2020; WHO; 2021).

Telemedicine practices, which started in the 1950s, came to the agenda in Turkey in the 2000s and were put into practice. In the action plan prepared by the Ministry of Health in 2006, four actions related to e-health were included and the implementation of Tele-Medicine systems was accepted as one of these actions (see Information Society Strategy and its annex approved by the High Planning Council Decision dated 11/07/2006 and numbered 2006/38, Official Gazette dated 28/07/2006 and numbered 26242). In 2007, teleradiology, telepathology, and teleECG services were established, and in 2008, the number of hospitals covered by the program was increased. The images created with the software installed on the laptop computer used by family physicians and the ultrasonography probe integrated into the computer were analyzed and reported by experts at a hospital. A teleconsultation application was implemented between the Gazi University Faculty of Medicine, Department of Pediatrics and ten health centers via the web (Onal & Kaya, 2020).

As of January 1, 2015, the e-Pulse system, through which the medical history of patients benefiting from health services can be accessed, has been put into use (e-Nabız, Republic of Turkey Ministry of Health, 2020b). With the 2015 "Directive on the Application Procedures and Principles of Telehealth Services," it was aimed to provide medical consultancy on all kinds of health problems that may arise in air and sea vehicles navigating within the Turkish Search and Rescue Region, to provide expert consultation when necessary and to conduct activities such as emergency health services (Çapacı & Özkaya, 2020). In 2019, with the COVID-19 pandemic, healthcare services in many health institutions started to be provided via telemedicine. A video call system was launched through e-Nabız, and it was aimed to enable COVID-19 positive or contacted persons to access online health services. The system was piloted in the cities of Ankara, Yalova, Kırıkkale, and Istanbul and implemented in family medicine centers in Samsun (Ministry of Health, 2021). In the Ege University Faculty of Medicine Hospital, Telemedicine Polyclinic System was put into practice to prevent delays in the follow-up of patients with chronic diseases due to the COVID-19 pandemic, and remote video examination service planned as a telehealth practice was initiated in many health institutions in Ankara to reduce the risk of COVID-19 transmission in different branches and to ensure the continuation of health services by protecting public health (Ege University, 2021).

In February 2022, the discussions on the provision of remote healthcare services in Turkey were addressed by the Ministry of Health and the "Regulation on the Provision of Remote healthcare services" numbered 31746 was published. The Regulation sets the legal framework for remote healthcare by regulating the procedures and principles for these activities.

Telehealth Applications in Primary Healthcare Services

Prenatal and Postnatal Care and Telehealth

Telehealth services are being used in the prenatal period to monitor the health status of the pregnant woman, provide genetic counseling, and monitor chronic medical conditions and in the postnatal period to monitor and promote breastfeeding. In the prenatal period, a pregnant woman is assessed to determine whether she is eligible for remote health care. Risky pregnancies are usually excluded from this service. Patients who are deemed suitable for remote monitoring are provided with a package containing items, such as a fetal pulse monitor, urine kit, and blood pressure kit. Nurses can follow-up the pregnancy of patients who make an appointment to receive virtual antenatal care (Wenata & Dira, 2022).

Chronic conditions during pregnancy can be monitored with telehealth applications. For example, with a glucometer that transmits measured blood glucose data to a secure server, the health professional monitoring the pregnant woman can receive notifications to review her blood glucose levels and electronically communicate recommendations to the patient for changes in diabetes management (Greıner, 2017).

Telehealth interventions to support breastfeeding are referred to as telelactation. It is implemented by supporting breastfeeding mothers using any real-time audiovisual technology available (e.g., smartphones, tablets, or computers) (Uscher-Pines et al., 2017). Studies have shown that telelactation increases mothers' perceived self-efficacy in breastfeeding and supports exclusive breastfeeding. The advantage of this service over face-to-face education is that mothers recovering after giving birth have the opportunity to access the service in their own homes without having to go to a healthcare institution with their babies, and their requests for problem solving can be met quickly. In this respect, it is stated that telelactation has preventive effects on early weaning and formula supplementation (Macnab et. al, 2012; Hubschman-Shahar, 2022). Telelactation services can be particularly beneficial for individuals living in rural areas (Uscher-Pines et al., 2020; Demirci et. al, 2019).

Geriatric Health and Telehealth Applications

Telehealth is important for geriatric health as it enables access to health services without leaving the home environment. Each component of telehealth can be used in the field of geriatric health. The vital signs of elderly individuals can be monitored using wearable devices, such as clothes, belts, watches, and glasses. Individuals wear these measuring devices on their body and either transmit the data to the health institution via a computer or do it via video conferencing (Gokce Kutsal, 2021). It is stated that monitoring elderly individuals with chronic diseases at home improves their quality of life, provides clinical improvement and reduces their symptoms, and increases their compliance with treatment (Armstrong et al., 2007). Telehealth services reduce health inequalities by giving older people living in rural areas the opportunity to access health information (Demir Avcı & Gozum, 2018).

With the sensors installed in the homes of elderly individuals, their well-being is secured by monitoring the activities carried out by the individual at home. Telecare devices that automatically call for help in the event of a fall or other domestic emergency (such as fall detectors worn as belts that detect a jarring sensation of sudden movement and changes in position from vertical to horizontal) increase the confidence of elderly individuals to live independently (Blythe et. al, 2005). Older people with cognitive impairments can receive assistance in daily activities by using systems that send a text message when the user approaches their front door, reminding them to pick up their keys, check their cell phone, or lock the door (Hawley-Hague et al., 2014).

Chronic Diseases and Telehealth Applications

Chronic diseases are seen as one of the main application areas of telehealth services. Telehealth applications for chronic disease management are used for diagnosis, treatment, home care, primary and secondary preventions, disease management, and palliative care (Hanlon et al., 2017). Informatics-based applications used in disease management can help patients maintain self-management of diseases, leading to a healthier process, reducing the workload on health care systems and reducing the cost of health services (Baran et al., 2022).

The best recommended model for telehealth in hypertension management is the combination of remote monitoring and transmission of blood pressure data with video consultation and education about lifestyle and risk factors (Omboni, 2020).

The medication and medical nutrition therapy, compliance with physical activity programs, and optimal glycemic control of individuals with diabetes can be monitored with telehealth applications, and appropriate measures can be taken at an early stage (Gürçay and Taskun Yılmaz, 2022). It was found that patients with diabetes who were followed-up at home with reminder text messages, and patient checks via text messages. Web-based education and follow-up programs showed a significant decrease in Hba1c levels, successful cognitive-social adaptation to the disease, and these practices positively affected diabetes self-management (Zhai et al., 2021). Another study found that web-based programs for nutrition tracking and physical activity promotion and monitoring can improve glycemic control, waist and hip circumference, functional capacity, physical activity level, and quality of life of patients with diabetes (Ming et al., 2016). With telehealth methods, such as photographic imaging and online communication via video conferencing, diabetic foot ulcers can be detected and prevented at an early stage (Hazenberget al., 2020).

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Similarity Index
The similarity index obtained from the plagiarism software for this book chapter is 9 %.

To Cite This Chapter:
Batı, S. (2021). Telehealth and its Place in Primary Care. In S.N. Guner, Y. Uzun & I. Cetin (Eds.), *Current Studies in Healthcare and Technology* (pp. 116-125), ISRES Publishing.

CHAPTER 10

Analysis of Patient Emotions by Deep Learning Approach

Fatma Nur UZUN, Yusuf UZUN

Analysis of Patient Emotions by Deep Learning Approach

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Introduction

Today, emotion detection is used in many fields. Emotions of users are used to reach objective evaluations on digital platforms. It has been observed that advertising channels or movie reviewers are starting to use real-time emotion detection to detect users' emotions. Real-time emotion detection was performed in projects developed using deep learning (DL) and artificial intelligence (AI) algorithms. In this way, it is possible to follow the emotional changes of the users simultaneously while watching a video or movie. As a result of the accurate results of emotion detection used in similar studies, its use in the field of health was also evaluated. The evaluation system of many hospitals is based on patient opinions as well as statistical values. Studies have shown that these assessments do not adequately detect the patient's emotions. Emotion detection studies using multiple datasets can explain most very complex patient reviews that indicate only a few emotions. In particular, it is of great importance to detect the emotions of patients who cannot express their emotions and to prevent erroneous emotion detections. This study aimed to address the problem of perception of multiple emotions as a result of emotion detection studies in the field of health.

Emotion detection is frequently used in applications such as human-computer interaction (HCI). Also, from emotion recognition systems, video games, animations, psychiatry, automobile safety, education, etc. it is used in many areas (Semerci et al., 2022). It has provided significant benefits in areas aimed at protecting human life. Human life has been significantly protected by detecting whether the driver is tired or not, thanks to emotion detection, and transferring it to the warning systems. In addition, it is predicted by emotion detection that patients or children with special needs will recover faster by taking their emotions into account during their rehabilitation training and following the right methods in treatment (Edo-Osagie et al., 2020). In addition, the convenience of emotion analysis has been used in the treatment of mental illness and in remote medical services. Similarly, with emotion analysis, it has been observed that in cases where human emotions cannot be clearly detected by the human factor, it is performed by means of a machine and gives us accurate results. For this reason, its use in the field of health has been frequently mentioned recently. The use of emotion detection has also been deemed necessary by hospital administrators to understand patient satisfaction in hospitals. In this way, it is aimed to better understand the patient's expectations by analyzing the emotions of the patients.

Emotional change of the patient can also be understood by methods such as electrocardiograms, detection of psychological signals and skin temperature analysis (Serrano-Guerrero et al., 2022). However, such processes are both costly and time consuming. In the field of psychiatry, emotion detection is used to detect diseases such as stress and venous thromboembolism (Sabra et al., 2018). Especially during emotion detection, the large number of data sets will enable the detection of emotions that are normally difficult to understand from facial expressions. Machine learning and deep learning-based algorithms were used to detect multiple emotions. More than one experiment was carried out.

Project Purpose

With the developed project, it is aimed to detect emotion both via photo and video and real-time instant camera. In this way, emotional changes of individuals can be followed in many ways and information will be provided to the necessary places. Sensitive monitoring of emotional change is planned. It is aimed to reach a more objective result by using more than one data set.

Project Significance

Emotion analysis is a popularly studied field in computer science for emotion recognition. For the interaction between human and computer to be more natural, computers are aimed to recognize human emotions. Although sentiment analysis is mostly used in the field of text mining, it has recently been the subject of studies in the field of computer vision. In the studies in the field of text mining, three feelings of the person about any subject, namely positive, negative and neutral, are generally taken as reference. Sentiment analysis in the field of text mining can be used in advertising, product marketing, current events, etc. It is done to extract short and meaningful information in the fields. Sentiment analysis studies in the field of computer vision are called Automatic Facial Expression Recognition, shortly FER (Face Expression Recognition). It has been observed that studies in this field play a major role in detecting the emotions of individuals over time. In the project, using computer vision applications, more than one emotion that the individual has at the same time is determined. In this way, it is prevented that the individual is limited to only one emotion while describing his emotions. In many areas, erroneous results have been prevented by identifying the emotions of people more accurately.

In an article examined, while the face recognition system was being designed, it was made available to researchers as open source and a dataset was created from 4 different databases. While creating the dataset, the CelebA (large-scale CelebFaces), FFHQ (Flickr-Faces-HQ Dataset), LFW (Wild Home dataset) and Youtube Faces dataset used by the researchers were used. A total of 300,000 images from these datasets were used for educational purposes, while 60,000 images were used for testing purposes (Dehghan et al., 2020; Oliver et al., 2015).

In the research, it has been concluded that visual intelligence can also measure the emotional state with its tracking and observation abilities around the world. In the pilot project initiated by the Chinese government, it is planned to make primary school children's learning more efficient by measuring the concentration they show during class lectures from their facial expressions (Khanbhai et al., 2021).

Data Set

In the emotion detection project, Open-CV, TensorFlow and Keras libraries were used extensively. The appropriate dataset (fer-2013) was found from Kaggle. The training set consists of 48*48 pixel grayscale 35,888 samples. The data were divided into 7 categories in total, as in Figure 1. (0 = Angry, 1 = Disgust, 2 = Fear, 3 = Happy, 4 = Sad, 5 = Surprise, 6 = Neutral). In this way, the emotional change of the patient was determined by reaching a more objective result. The project was carried out in such a way that patients who could not express their emotions clearly could perceive more than one emotion at the same time. The training set consists of 35,888 examples. train.csv contains two columns "feel" and "pixel". The "Emotion" column contains a numerical code ranging from 0 to 6 for the emotion present in the image. The "Pixels" column contains a string in quotation marks for each image. A facial emotion recognition system was handled in a two-stage process. These processes are face detection (limited face) in the image, followed by emotion detection on the perceived limited face. Two techniques were used to carry out these processes. The Haar feature-based classifiers used provide good front-side detection in an image. It is real time and faster compared to other face detectors. The data set was separated according to the train test split method. The 80% training dataset is set to be the 20% test dataset. 28709 images were used for training. For the test, 7178 images were used.

Figure 1

Fer-2013 Data set (https://www.kaggle.com/datasets/msambare/fer2013)

Artificial Intelligence

Today, many studies are carried out in the fields of artificial intelligence. Artificial intelligence, which is the type of intelligence observed in machines, unlike other living things; It functions in areas such as image processing, data science, machine learning

(ML), computer vision and deep learning (Artificial Intelligence, 2022). Artificial intelligence is briefly defined as systems that imitate human intelligence and can regularly improve themselves in order to perform the tasks assigned to it. Chatbots, smart assistants, facial recognition systems, autonomous cars, smart home systems and recommendation engines are shown as examples of common usage areas of artificial intelligence. (AI, 2021). Artificial intelligence emerges in many areas that will make our work easier in our daily life. When it comes to Artificial Intelligence, although multifunctional robots that take over the world in the human mind come to life, artificial intelligence is not designed to replace humans. Rather, it is designed to make people's jobs easier and to improve their abilities significantly. For this reason, it is used as a facilitator in many sectors.

Reasons for the widespread use of artificial intelligence are shown to be affordable, high-performance computing, access to a lot of data for training, minimizing risks and creating a competitive environment. Artificial intelligence has also been used in the health sector for a long time. Using artificial intelligence algorithms, it was possible to detect liver, prostate and bowel cancer diseases with 94 percent accuracy (Artificial Intelligence Uses, 2020). In this way, the use of artificial intelligence in a disease where early diagnosis is important, such as cancer, is of great importance. Similarly, the work of healthcare professionals has been facilitated by medical imaging systems used in many areas. While detecting emotion, many technologies brought by artificial intelligence were used based on studies in which artificial intelligence was used in the field of health. Sub-branches of artificial intelligence such as deep learning, machine learning and computer vision have been used. Artificial intelligence, while detecting the emotions of patients, achieves more accurate results by comparing them with patients with similar emotions.

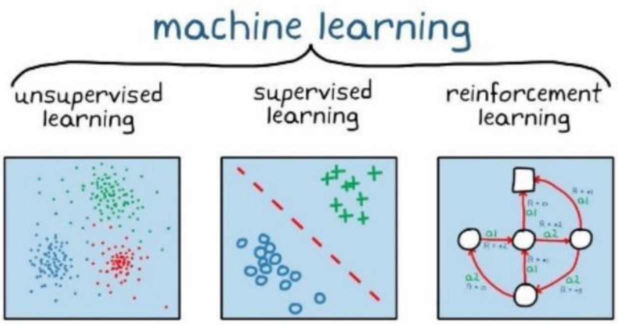
Machine Learning

Machine learning is defined as a computer's use of mathematical models to directly enable learning (Machine Learning, 2021). It is used for processing and analyzing big data. It uses the patterns it has developed for this purpose to create a predictable data model. Similar to the development of people by gaining experience, more accurate results are obtained in machine learning as the amount of data and experience increases (Machine Learning, 2021). Machine learning is frequently preferred due to the fact that Bayesian analysis is highly preferred, the tendency towards machine learning is increasing and its use in data mining is widespread. Situations such as the increase in data types and volumes, performing computational operations that are both cheap and powerful, and storing data economically have led to an increase in the importance of machine learning (SAS, 2021). Machine learning is one of the subsets of artificial intelligence. A computer created with artificial intelligence thinks like a human and performs the tasks assigned to it. One way to train a computer to perform human-like activities is to use a neural network consisting of a set of algorithms modeled on the human brain. With machine learning, predictive analysis is performed using a static dataset. Since the static dataset is used, it needs to be refreshed to be updated.

Machine learning; it has advantages such as improving the user experience, predicting the behavior of individuals, ensuring and improving data integrity, reducing the risks that may occur and reducing the cost. In the emotion detection project, machine learning was used to increase efficiency and classify data more accurately. Machine learning is divided into a number of terms as supervised learning, unsupervised learning and reinforcement learning. In supervised learning, datasets are processed with labels. The processed data “trains” the machine, improving its predictive ability. Supervised learning is a learning method in which the content of the dataset is known. Problems that may occur are solved by observing continuous outputs. In unsupervised learning, datasets are processed without labels. Unsupervised learning types are divided into two as clustering and association. There are relationships between the data by grouping the data in clusters. It is the method used when little or no information is available about the data. Therefore, there is no certainty in unsupervised learning. In reinforcement machine learning, artificial intelligence makes consecutive decisions and is not controlled by humans. Unlike supervised machine learning, data does not need to be labeled or corrected. The purpose of reinforcement machine learning is discovery.

Figure 2

Types of machine learning (Types of machine learning, 2022)



The machine learning process is based on collecting data, training the model, validating the model using the test set, and interpreting the results. Model training takes place by training data sets that are divided into training sets and test sets. To achieve the highest accuracy, some adjustments should be made, such as adjusting the amount of dataset, increasing the number of training sessions, and making necessary adjustments to the dataset. Factors such as predicting unexpected situations and values, determining the appropriate model for training and providing classification are realized with machine learning. Machine learning, which is used in the field of health as well as in many sectors, is also used in the emotion detection project.

Deep Learning

Deep learning is a type of machine learning and artificial intelligence method that enables digital systems to learn and make decisions based on unlabeled data. It is used when creating multi-layer artificial neural networks (ANN) in the fields of object, sound and image recognition and natural language processing. The difference between deep learning and machine learning is that coded rules are not used. Instead, it performs the learning process by using data such as pictures, videos, audio and text. Deep learning is flexible. The larger the size of the data used in deep learning, the higher the accuracy of the predictions made. Artificial neural networks are used during this process. As a result of training the data set, artificial neural networks can generalize about the data set and collect external information. Later, when he sees the examples he has never encountered, he can make a decision about those examples with the information he has learned (Luckey et al., 2020). At the same time, neural networks can process large amounts of nonlinear data to solve complex problems.

Artificial neural networks; Similar to the human nervous system, the neuron consists of weights, bias and activation function. Billions of neurons in the human brain process the necessary information through small electrical signals and enable us to perform our daily activities. In artificial neural networks, each neuron processes the inputs that come to it and transfers the results to the next neuron for the continuation of the process (Artificial Neural Networks, 2019). Thus, it is ensured that the necessary reactions are given by obtaining instant results. Similar to a brain filled with digital neurons, artificial neural networks interpret and respond to situations faced by digital systems, similar to our nervous system. Weights are given according to the importance of the information. Therefore, seeing low weights in a place indicates the insignificance of the information there. Deviation, on the other hand, is the linear component applied to these weights, except for the weights applied to the inputs. The activation function, which has different types, converts input signals to output signals. It allows the model to learn nonlinear structures by breaking the linearity. Commonly used are the sigmoid, relu (rectified linear units) and softmax activation functions. Relu and softmax activation functions were used in the emotion detection project.

Convolutional Neural Network

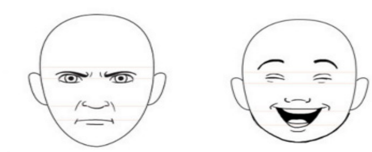
Convolutional neural networks (CNN) are a type of deep artificial neural network that is frequently used in image recognition and processing problems. Its use in pictures and video formats around the world gives very successful results. CNN first converts the images that come to it as input into a matrix format that can be defined by the computer. In this way, it is ensured that small details are captured. The system detects which label the picture has by considering the differences in the matrix and learns the effects of the differences on the label during the training. He then makes predictions for new pictures using the information he has learned. CNN has some layers that are responsible for performing these operations. In the convolution layer, the feature map of the picture is created by passing the picture through the filter. The sizes of the filters may vary according to the picture. Thanks to the attribute map, necessary operations can be performed by creating fewer connections.

Concept Mapping Model

In Figure 3, detection is provided by using matrix differences on different face types used as a data set during emotion detection. The training will be carried out by learning that the matrix differences in the mouth, eye and eyebrow circles of the model applied to the image have a great effect on the label. However, the forehead and ear regions appear to be the same for both images. Therefore, the effects of these values on training and forecasting are expected to be small. Thanks to the convolution layer, only the necessary and important features are determined and the features that do not make a difference are not taken into account.

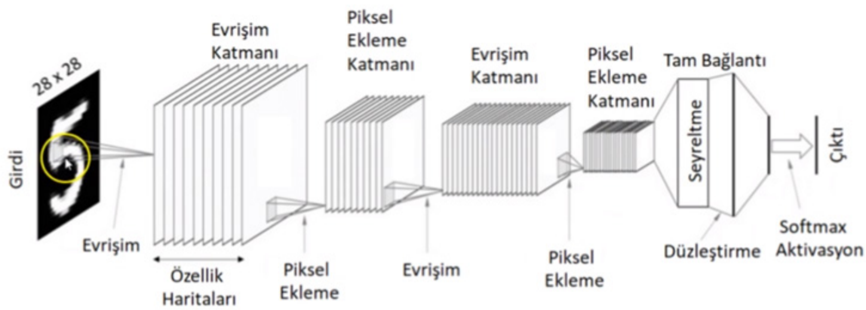
Figure 3

Angry and smiling (Convolutional neural networks, 2020)



The pooling layer is applied to the feature matrices. The number of parameters is reduced by performing subsampling. It provides the perception of features that do not change according to changes in scale and direction. It provides control of over-fitting by reducing the amount of computation in the network. Although the method used in the pooling layer is max_pooling, methods such as mean_pooling and min_pooling are also used. In the mean_pooling method, the process is performed by taking the average. mean_pooling and max_pooling were used in the emotion detection project. The flattening layer, which is one of the CNN layers, transforms a two-dimensional data into a vector. It can be used more than once in the model. In the fill layer, pixels are added to preserve the original size of the picture as a result of decreasing the size of the picture as the convolution layers are applied. If the number of steps is set to 1, one-by-one navigation is provided between the pixels. Classification is performed at the full link layer. In the dilution process, randomly selected neurons are ignored during training. As the number of hidden layers and neurons increases, the depth increases. In other words, the perceptibility of complex structures increases. Figure 4 shows the convolutional neural network structure.

Figure 4
Convolutional neural networks (CNN, 2020)

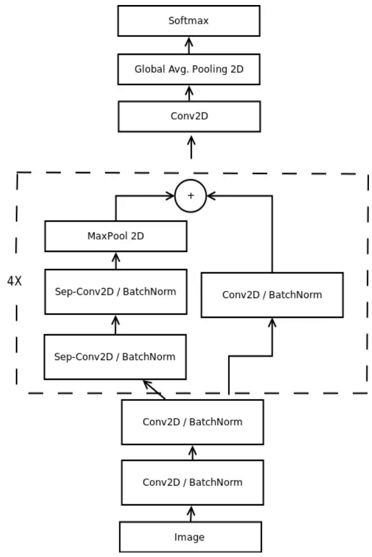


Basically, there are continuous improvements on the CNN algorithm, which has a structure like Figure 4. LeNet, AlexNet, VGGNet, GoogLeNet, ResNet and ZFNet are examples of some well-known CNN architectures today.

Mini_Xception Model

The Xception CNN Model (Mini_Xception 2017) was used in the emotion detection project. The Mini_Xception model, whose general structure is shown in Figure 5, used in many projects similar to emotion detection, is different from the CNN model. Common architectures use fully connected layers at the end where most of the parameters reside. Also, standard convolutions are used. One of the modern CNN architectures, the Xception model benefits from a combination of two of the most successful experimental assumptions in CNN. These are now separable convolutions in terms of the use of modules and depth (Kim, 2014).

Figure 5
Mini_Xception model (Mini_Xception, 2020)



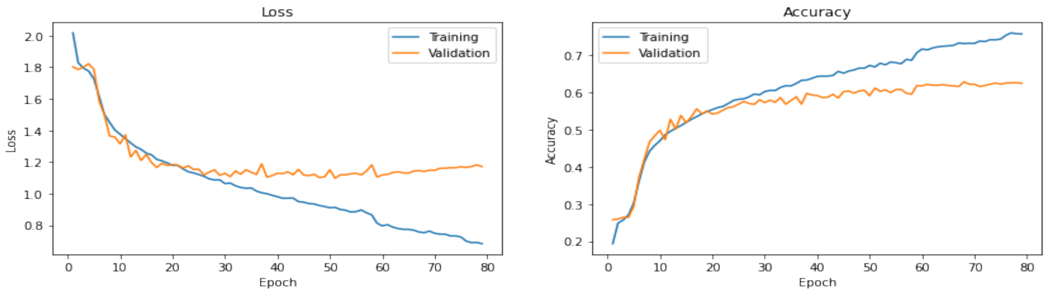
In the Mini_Xception model used in the project, it is noticed that the central block is repeated 4 times in the design, as seen in figure 5. Some of the techniques used while training the model are Data Augmentation, Kernel_regularizer, Batch Normalization, Global Average, Pooling, and Depth Separable Convolution. ReLU and Softmax functions are used as functions in the activation layer.

Education Result

As a result of the training process, the accuracy value generally increases, while the loss value decreases in general. Although there are changes in the increase and decrease values, this situation does not affect the general. The epochs value for training is set to 100. As a result of the training process, the training accuracy was approximately 91% and the test accuracy was approximately 84%. In order to increase these percentage values, necessary changes were made on the epochs value and retraining of the trained data was performed. As a result, an increase in the accuracy value was observed.

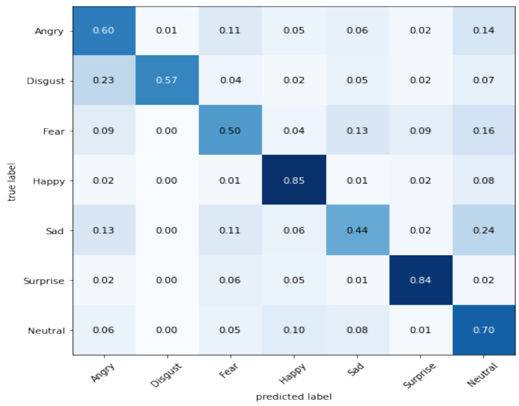
As a result of the training, the distribution of emotions resulting from the emotion detection of the patient and the responses given by the patient are compared. As a result, the accuracy of the model is compared objectively. Experiments on different CNN models are planned. According to the results obtained from the models and the answers given by the patient, it was deemed appropriate to use the model that gave the most accurate result. It has been observed that the Mini_Xcepition model gives the correct result as a result of the evaluations made for emotion detection. Figure 6 shows the graph of change in accuracy and loss values as a result of training the model.

Figure 6
Loss and accuracy change graph



According to Figure 6, while the loss value decreased during the training, the accuracy value increased. The error matrix, which is frequently used in machine learning, was used in the project. The error matrix allows us to evaluate the performance of classification models. Estimates of the target attribute and actual values are compared. The error matrix of the emotion detection project is given in Figure 7. According to the error matrix, there was more confusion between the expression of disgust with the expression of anger, the expression of frightened and the sad expression, and the neutral expression and the sad expression. The neutral expression was the most difficult to understand. In order to reduce the confusion in the error matrix, it is considered to increase the data set or make the necessary improvements.

Figure 7
Error matrix

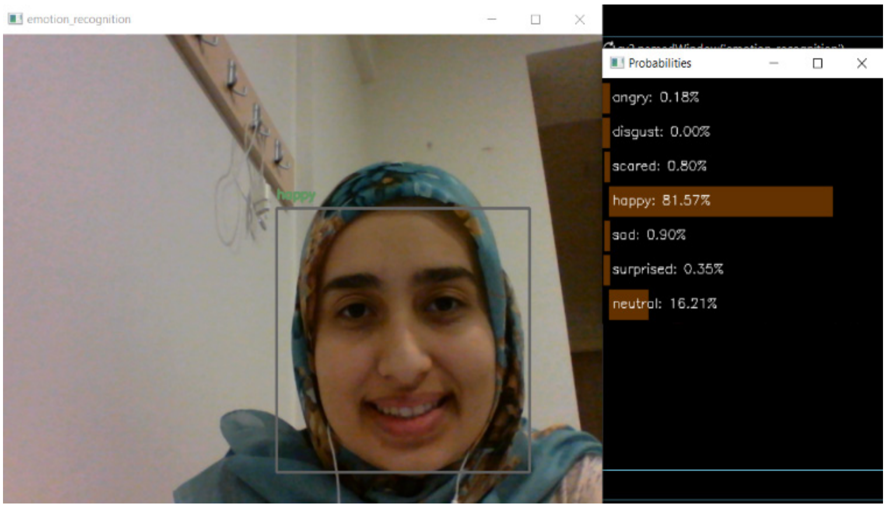


As seen in Figure 8, emotion detection is performed on more than one image depending on the coordinate location. The emotions of individuals are detected in real time via video. The simultaneous ability of the project to detect emotion enables the perception of instant emotional changes. Since emotional changes can change instantaneously in psychiatry clinics and private patients, simultaneous detection will provide more accurate results. It is planned to detect the instant emotions of individuals who have difficulty in moving their facial muscles. It was observed that the patients who came with their parents had difficulty in expressing their own feelings. In this way, the emotions of individuals who cannot express their emotions clearly will be detected by the machine and transmitted to the hospitals.

Figure 8
Image output

The data set used for the test was taken to include more than one emotion. Experiments have been made on sick individuals in real time and the desired results have been achieved. In Figure 9, the output with real-time emotion detection is given.

Figure 9
Real time code output



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To Cite This Chapter:
Uzun, Y. & Uzun, F.N. (2023). Analysis of Patient Emotions by Deep Learning Approach. In S.N. Guner, Y. Uzun & I. Cetin (Eds.), *Current Studies in Healthcare and Technology* (pp.126–138). ISRES Publishing.

CHAPTER 11

Web-Based Apps and Augmented/ Virtual Reality for Anatomy Learning

Betul DIGILLI AYAS

Web-Based Apps and Augmented/Virtual Reality for Anatomy Learning

Betul DIGILLI AYAS

Necmettin Erbakan University

Introduction

A thorough understanding of anatomy is crucial in medical education and is regarded as a fundamental subject for precisely acquiring clinical and surgical practices (Singal et al., 2020). The study of anatomy is included in the initial years of medical education to establish the fundamentals necessary for clinical training and application (Turney, 2007). Cadavers, combined with theoretical lectures, have been a traditional approach to developing anatomical knowledge among medical students over many centuries. Even today, the dissection or prosection of cadavers is still widely recognized as the most effective method for learning anatomy (McLachlan, 2004). However, the ongoing advancements in science and technology significantly alter the nature of the learning process (Kenski, 2003). As a result, there was a transition from conventional teaching methods to innovative and diverse teaching techniques (Boff et al., 2020). In addition, the global education, health, and economic sectors have been significantly impacted by the Covid-19 pandemic that emerged in recent times. Various countries have implemented social and physical distancing policies as a preventative measure to curtail the spread of the disease.

Consequently, many schools and universities have shut down, affecting over 91% of students worldwide and experiencing disrupted education (UNESCO, 2020). Furthermore, the closure of anatomy labs and classrooms due to the pandemic has discontinued theoretical and practical lessons involving cadavers and models. Thus, there was an increased urgency to explore new technological teaching methods as a substitute for cadaver dissection in anatomy instruction at medical schools. Therefore, several universities have resorted to distance education as a substitute. However, the anatomy course faced challenges adjusting to remote learning methods because its practical training was conventionally dependent on cadaver dissections (Santos et al., 2022). Hence, some of the supplementary technologies that have been developed are currently under investigation (Singal et al., 2020; Wish-Baratz et al., 2020). Besides the negative impacts of the Covid-19 outbreak and its aftermath, the literature suggests significant benefits and prospects for incorporating diverse technological methods in teaching anatomy (Longhurst et al., 2020; Smith & Pawlina, 2021).Furthermore, there has been a proliferation of technological tools for teaching and learning anatomy due to the strong preference of today's younger students for technology-driven approaches (Border, 2019; Clunie et al., 2018). Within this framework, students are more involved in generating novel approaches to learning (Farias et al., 2015). Consequently, there has been a substantial rise in the utilization of digital resources for teaching anatomy in the past twenty years (Trelease, 2014; Trelease et al., 2020).

With technology constantly progressing rapidly, there are revolutionary methods to study anatomy (Uruthiralingam & Rea, 2020). The literature on anatomy teaching mentions several types of technological resources, which include (Santos et al., 2022):

- 3D printing
- Extended reality (XR)
  - Virtual reality (VR)
  - Augmented reality (AR)
  - Mixed reality (MR)
- Digital tools – Web-based applications
  - Social media; Youtube, Facebook, etc.
  - Audiovisual resources; Screencasts.
  - Digital platforms
- Other technological resources
  - Ultrasound
  - Quick response code (QR code)
  - Audience response system (ARS) – Kahoot! Etc.

Various technologies, techniques, and methodologies are employed in anatomical education, but augmented and virtual reality with web-based apps have gained significant attention and popularity (Barry et al., 2016; Uruthiralingam & Rea, 2020). These emerging technologies are increasingly gaining popularity, making them valuable alternative options for educators (Duarte et al., 2020).

Extended reality (XR)
(Virtual reality+Augmented reality+Mixed reality)

Extended reality (XR) refers to technologies that offer immersive experiences by merging the physical and virtual dimensions. This term encompasses human-machine interactions and computer-generated environments, from incorporating virtual objects into real-world settings to completely immersive digital experiences (Fast-Berglund et al., 2018). The term "XR" is used to describe a spatially immersive ecosystem that encompasses virtual reality (VR), augmented reality (AR), and mixed reality (MR) hardware collectively. The purpose of this ecosystem is to facilitate immersive learning experiences. The studies were grouped as XR when the visualization technologies created immersive 3D depictions of the human body, which enabled a direct comparison between these methods and traditional 2D teaching techniques (Moro et al., 2021).

Virtual Reality: The individual is completely immersed in a synthetic environment, which they experience through sensory stimulation such as sight, hearing, and movement. This stimulation imitates real-world properties and is facilitated by high-quality, continuously updating head-mounted displays, stereo headphones, and motion-tracking systems (Moro et al., 2021).

Virtual reality is a sophisticated interface for interacting with users and an operating system facilitated by graphical resources and computer-based applications. This interaction is achieved through computational techniques and equipment designed to immerse individuals in three-dimensional (3D) environments, allowing them to interact with the virtual elements in real-time (Tori & da Silva Hounsell, 2020).

Augmented Reality: AR is a technology that incorporates digitally created virtual elements into the physical environment, and it is defined by the simultaneous existence and interaction of real and virtual objects (Azuma et al., 2001). AR involves projecting digital models onto the real world using a camera and screen, such as a smartphone or tablet. As a result, the user can engage with both the tangible and virtual components of their surrounding environment (Moro et al., 2021). The categorization of AR can be based on how the user perceives the mixed world:

When computer-generated virtual objects can be visualized directly by the human eye, either by merging them with real-world video or integrating them seamlessly into the environment, it is referred to as direct vision or immersive. Conversely, when real and virtual images are blended in a video and presented to the individual through a device like a monitor or a projector without precise alignment, the resulting reality is categorized as indirect or non-immersive (Santos et al., 2022).

While VR aims to provide a fully immersive experience where users are completely immersed in a simulated environment, AR does not necessarily offer the same level of immersion. AR allows for the overlay of virtual objects onto the real world, but it still maintains a connection to the user's physical surroundings. The user remains aware of the real world while interacting with virtual elements in AR, which sets it apart from the fully immersive nature of VR (Tori & da Silva Hounsell, 2020).

Mixed Reality: AR involves superimposing digital information onto real-life objects, whereas MR offers an added level of engagement. The MR technology projects holographic images anchored to real-world objects, allowing users to interact with them as physical objects (Moro et al., 2021).

Mixed reality combines features from both VR and AR, blending computer-generated 3D virtual objects with the real world. It enables users to interact in real time using technological devices. As a result, MR creates novel environments that merge virtual and physical elements, seamlessly integrating virtual components into reality or real-world elements into the virtual realm. These elements coexist and interact, enhancing the overall experience (Rodello et al., 2010).

Among the tools utilized for visualizing 3D models in anatomy through extended reality technology, some examples include:

- Virtual dissection table (Sh et al., 2019).
- Microsoft HoloLens (Weeks et al., 2021).
- Oculus Rift VR - MR equipment based on the head-mounted display system (Stepan et al., 2017).
- Magic mirrors screen-based systems: It enables users to investigate anatomical structures alongside medical images related to their own body using the Microsoft Kinect platform (Ma et al., 2016).

The absence of variance in learning outcomes among AR, VR, and traditional educational methods is a favorable finding that supports the potential use of these groundbreaking technologies in educational settings. Furthermore, incorporating AR and VR technologies into teaching may greatly benefit students' spatial awareness and comprehension of anatomical structures in 3D (Moro et al., 2021). Nevertheless, it is crucial to introduce assessment strategies that ensure fairness when implementing new learning tools. For example, some researchers have found that VR may be disadvantageous for students with poor visuospatial ability compared to traditional learning anatomy involving tangible objects (Wainman et al., 2021). The virtual dissection chart, such as Anatomage, can potentially enhance student performance (Rosa et al., 2020). However, producing individualized models for each anatomical unit can be expensive. As a result, due to the limited purchase of these tables, they are rarely utilized by groups of more than eight students and during brief periods (Fyfe et al., 2018).

In the present times, literature depicts the existence of alternative platforms that encompass not only anatomy videos and texts but also provide an augmented reality (AR) experience. Furthermore, these platforms possess a multifunctional capability that combines various internet-dependent technologies within user-friendly software, such as the Complete Anatomy platform (Motsinger, 2020). In addition, Sketchfab is another frequently utilized platform for hosting interactive 3D content (Erolin et al., 2019). These supplementary technologies offer straightforward usability and require minimal financial resources, making them suitable for integration into new medical curricula.

Infrastructure-intensive resources such as VR, AR, and MR require complex handling, additional physical equipment, and substantial financial investment. For instance, VR necessitates a head-mounted display system (Stepan et al., 2017), while MR technologies utilize equipment like Microsoft Kinect and 3D televisions (Messier et al., 2016).

While studies demonstrate some degree of learning effectiveness with these technologies, their accessibility is limited compared to straightforward computer platforms. Additionally, both VR and AR experiences were found to have similar learning efficacy. However, VR was associated with dizziness and nausea in several students (Ammanuel et al., 2019; Birbara et al., 2020). Consequently, teachers favored the utilization of AR due to these concerns.

Certain studies suggest that AR and VR do not significantly enhance students' learning effectiveness compared to traditional methods (Duncan-Vaidya & Stevenson, 2021; Moro et al., 2021). However, it is worth noting that the AR experience can still be efficacious even without complete immersion (Chytas et al., 2022). Nevertheless, perhaps the critical consideration lies not in efficacy alone but in understanding the requirements and potential for practical application.

Nowadays, efforts have been made to enhance the head-mounted display system of VR. For instance, introducing new equipment like the Oculus Quest 2 (Facebook Technologies) aimed to improve the VR experience. However, these attempts have proven unsuccessful, as the new head-mounted display system failed to address the issues of its predecessor and led to additional health complications (Machkovech, 2020; CPSC, 2021). Consequently, these facts highlight the limited accessibility of VR technologies, particularly in the context of developing countries, and their potential to cause health issues.

Digital tools – Web-based applications

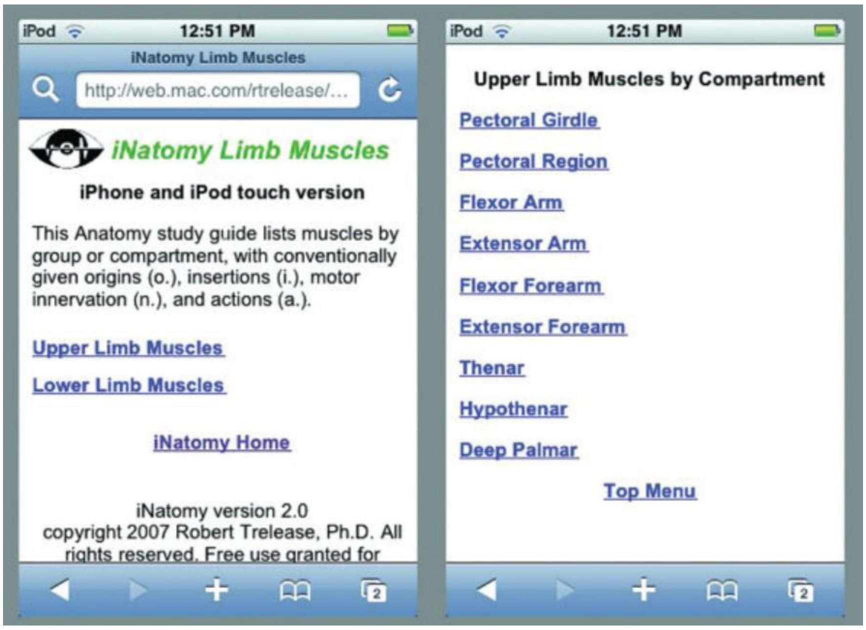
Digital tools revolve around technological resources that rely on internet connectivity for their operation, whether it involves downloads or continuous access. Similarly, they can be virtually accessed and viewed on various computer equipment, from laptops to smartphones and tablets. Moreover, most of these technologies incorporate audiovisual or interactive content (Santos et al., 2022).

Integrating new technologies into everyday use is a multifaceted process known as the Diffusion of Innovations (DOI) (Rogers, 2010). An excellent illustration of the diffusion in the mid-1990s, widely recognized among anatomists, is the gradual and widespread acceptance of the personal computer (PC), multimedia, and the World Wide Web for anatomical informatics and educational purposes. PCs have become indispensable tools in various fields, enabling learners to carry out their everyday academic tasks, from attending lectures and participating in laboratory work to engaging in distance learning. Over the past few years, portable or mobile personal computing devices have emerged as viable additions to using PCs in education (Trelease, 2008).

This project on Diffusion of Innovations (DOI) was a practical demonstration of applied anatomical informatics by showcasing how anatomical information in text, clinical imaging data, histological images, and educational videos could be conveniently transferred and utilized on the iPhone and iPod touch. These educational multimedia resources could be transferred to an iPhone directly from a PC using the standard iTunes software synchronization process or accessed through a wireless connection to web servers. An instance of this is the iNatomy limb muscles flashcard application, which can be accessed and run on an iPod touch using the Safari Web browser. In addition, it can be downloaded directly from a public website (Figure 1). The successful utilization of podcasting and smartphone technology relies on educational developers' proficiency and ability to seamlessly integrate these tools with other learning resources within targeted instructional programs (Trelease, 2008).

Figure 1

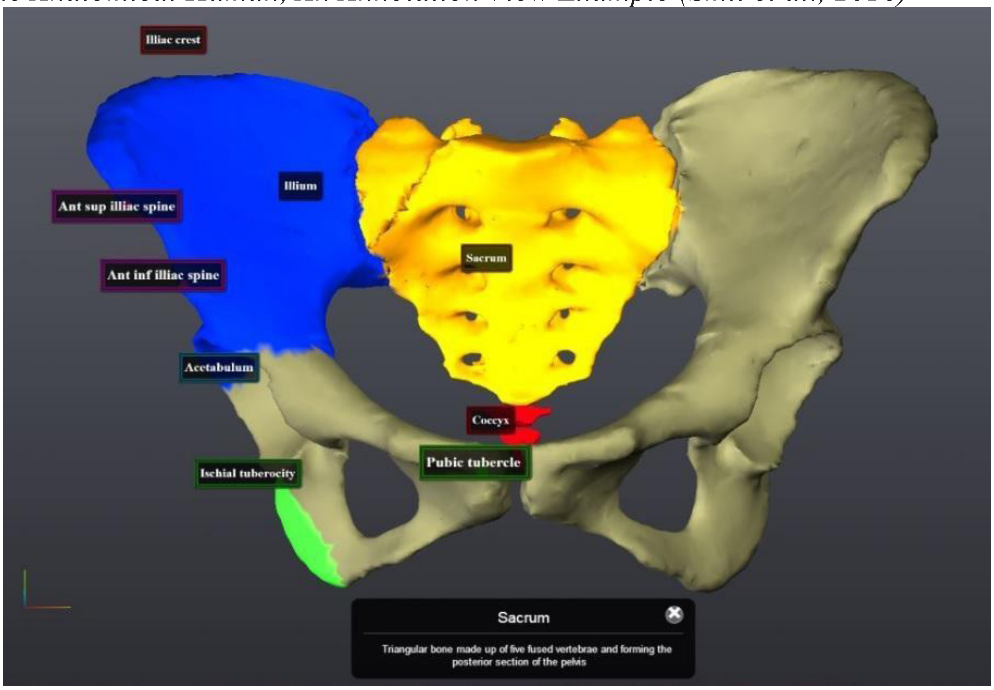
Screen Capture Images of the iNatomy Limb Muscles Flashcard Application Running on an iPod Touche (Trelease, 2008)



The Essential Skeleton 4, another web-based mobile application, offers a comprehensive 3D representation of the skeletal system. It enables users to zoom in and examine bones from various perspectives. By tapping on a particular bone, its name is displayed. Moreover, a related information box appears upon bone selection, providing additional details such as pronunciation and location. Furthermore, users can access specific bone structures and joint associations by selecting the information icon within the information box. The Essential Skeleton 4 app is free of charge and compatible with both Apple and Android devices. (Bice et al., 2016). Bice et al. (2016) found that incorporating mobile applications improved students' grades on skeletal exams. In addition, students expressed a positive reception towards using technology in their classes and appreciated the convenience of accessing the applications on different mobile devices.

The Online Anatomical Human (OAH) is a web-based application that utilizes authentic human anatomy and incorporates medical image data, offering linked 2D and 3D views that users can freely explore and interact with. This application stands out as the sole platform that supports real medical imaging data in both 2D and 3D perspectives. Its primary objective is to be an educational resource accessible to anyone with a modern web browser. In addition, users can annotate specific regions, add comments, and include hyperlinks to different media (Figure 2). The platform continually aims to expand its information and educational value by ensuring access to medical experts (Smit et al., 2016).

Figure 2
Online Anatomical Human, An Annotation View Example (Smit et al., 2016)



Another digital tool, social media platforms like YouTube (owned by Google LLC), serve as primary examples of this category, providing an online platform for sharing videos (Mustafa et al., 2020). Unfortunately, while a vast amount of human anatomy content is available on this platform, there is a scarcity of high-quality content or videos uploaded by professors. Typically, students can access the videos on the platform like any other user, or tutors can create and share customized materials directly. Consequently, the platform is an alternative to traditional in-person classes (Raikos & Waidyasekara, 2014).

Facebook can be utilized as a digital educational tool, offering various opportunities for communication, collaboration, and content sharing. Teachers and students can create groups or pages to facilitate discussions, share resources, and engage in online learning communities. Facebook Live can be used for live-streaming classes or presentations, allowing real-time student interaction. Additionally, Facebook Events can help organize educational activities, such as webinars or workshops. However, it's crucial to consider privacy and data security when using Facebook in an educational context (Jaffar, 2014).

The literature also mentions audiovisual resources, including screencasts. Screencasting is a teaching method that involves recording a computer's or mobile device's screen while providing a narration or commentary. Educators can create videos demonstrating various concepts, processes, or software applications. Screencasts can deliver lectures, explain complex topics, provide step-by-step tutorials, or showcase digital resources. This teaching method offers several benefits. Firstly, it allows for flexibility as educators can create screencasts at their convenience, and students can access them anytime, anywhere. It also provides a visual and auditory learning experience, making it easier for students to understand and retain information. Screencasts can be paused, rewound, and rewatched, allowing students to learn at their own pace. Additionally, screencasts can be easily shared and accessed repeatedly, serving as valuable reference materials (Ghilay & Ghilay, 2015).

The literature reports that replicating the drawing component of traditional anatomy lessons through screencasts has enhanced the student experience and knowledge retention, resulting in its growing popularity among students. Furthermore, the mobile nature of screencasts enables students to utilize this resource according to their preferred learning style at a time and location that is most suitable for them (Pickering, 2015).

Another term for digital tools is digital platforms. Digital platforms in education refer to online platforms or software applications designed to facilitate teaching and learning activities. These platforms provide a range of tools, resources, and features that support various aspects of education, including content delivery, interaction, collaboration, assessment, and administration. They also enhance access to educational resources, promote online collaboration, personalize learning experiences, and facilitate remote or blended learning environments. In addition, they offer convenience, flexibility, and diverse learning opportunities for students and educators alike (Alanzi & Alhalafawy, 2022). Some of them have been specifically designed to be accessed through smartphones, such as applications that provide 3D anatomical content or essential theoretical texts (Mansouri et al., 2020).

Jamboard, a collaborative digital whiteboard platform developed by Google, can be a valuable tool in medical education. For example, Jamboard can help study anatomy due to its interactive and visual features. Here are some specific ways Jamboard can be utilized for anatomy education:

1. Labeling and Annotating: Instructors or students can upload anatomical images or diagrams onto the Jamboard canvas and use the drawing tools to label different structures. This allows for a hands-on approach to learning anatomy, where students actively identify and label anatomical parts (Figure 3).

2. Virtual Dissections: Jamboard can simulate virtual dissections instead of traditional physical dissections. Instructors can upload high-resolution images or diagrams of anatomical structures and guide students through dissection by highlighting and explaining different layers or structures. Students can collaborate and contribute their observations and questions in real time.

3. Conceptual Understanding: Anatomy involves understanding the spatial relationships between various anatomical structures. Jamboard's canvas provides a platform to create concept maps, mind maps, or flowcharts to illustrate and connect different anatomical concepts. This visual representation aids in conceptual understanding and retention.

4. Clinical Case Studies: Jamboard can be used to analyze and discuss clinical case studies with an anatomical focus. Instructors or students can upload relevant patient imaging (e.g., X-rays, CT scans, MRI) and annotate the images to highlight specific anatomical abnormalities or structures related to the case. Collaborative discussions can help students apply their anatomical knowledge to real-world scenarios.

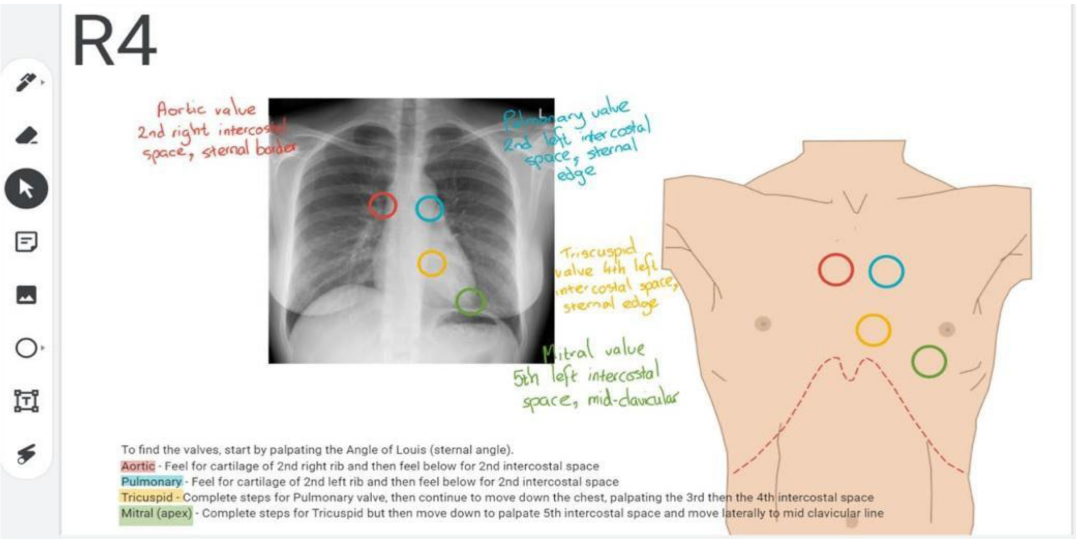
5. Interactive Quizzes and Review Sessions: Jamboard allows instructors to create interactive quizzes or review sessions for anatomy topics. Instructors can present questions, diagrams, or images on the board, and students can use the drawing tools to indicate their answers or annotate the structures being discussed. This active participation enhances recall and reinforces learning.

6. Group Projects and Presentations: Jamboard facilitates group projects and presentations on anatomy topics. Students can collaborate to research and compile information on a specific anatomical system or structure and then present their findings using the board's drawing tools, text boxes, and multimedia elements.

7. Remote Learning: Jamboard is especially beneficial for remote anatomy education. Instructors can share the board with students, allowing them to access and contribute to the material from their devices. In addition, distant learners can actively engage in discussions, labeling, and concept mapping, ensuring they have access to interactive learning experiences.

Jamboard, with other resources such as textbooks, interactive anatomy software, or physical models, provides a well-rounded anatomy learning experience (Sweeney et al., 2021).

Figure 3
An Example of Jamboard Slide (Sweeney et al., 2021)



Video conferencing digital platforms like Zoom, Microsoft Teams, or Google Meet are widely used for synchronous virtual classes, webinars, or remote meetings. They enable real-time communication, screen sharing, and participant collaboration. In most research studies on online teaching in medical education, it has been observed that online teaching is effective and beneficial for students. However, in contrast to these findings, most students preferred discontinuing online teaching after the lockdown period. This preference could be attributed to insufficient planning, the absence of well-developed teaching modules, and inadequate supporting infrastructure, including unreliable internet connections (Roy et al., 2020).

In a survey conducted among students to determine the approach they took when faced with challenges in learning anatomy, it was found that a significant majority (70%) relied on web-based platforms, such as search engines (62%) and social media sites (10%), to obtain information. On the other hand, 29% of students opted for suggested anatomy textbooks as their solution, whereas 5% mentioned their intention to contact their instructor for assistance. Consistent with earlier research findings, most students (78%) identified YouTube as their primary source for accessing anatomy-related videos. Medical websites were chosen by 8% of the respondents, while Facebook and other social media platforms (22%) were considered beneficial depending on the topic in question (Barry et al., 2016).

Conclusion

Studies indicate that emerging technologies do not negatively impact learning or assessment outcomes and can be effective alternatives to conventional teaching methods. Consequently, educators in medical sciences may consider integrating virtual or augmented reality as supplementary instructional tools.

In the wake of the pandemic, anatomy teachers need to repurpose and enhance internet-based resources and utilize platforms that incorporate AR and instructional videos.

Preferably, internet-based technologies should encompass versatile online platforms that offer a combination of AR capabilities and anatomy videos created by university instructors.

Simultaneously, these resources are both cost-effective and capable of delivering quality education. Consequently, they can be effectively incorporated into new medical curricula.

Furthermore, due to students' widespread acceptance of these innovative technologies, there will be an increase in the availability of well-crafted, multiplatform resources. Thus, students can easily access and acquire essential information in numerous fields, including anatomy, from any location at any time.

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To Cite This Chapter:

Digilli Ayas, B. (2023). Web-Based Apps and Augmented/Virtual Reality for Anatomy Learning. In S. N. Guner, Y. Uzun & I. Cetiner (Eds.), *Current Studies in Healthcare and Technology* (pp.139–152). ISRES Publishing.

CHAPTER 12

Biosensor Technologies in the Context of Medical Physiology

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Biosensor Technologies in the Context of Medical Physiology

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Introduction

Physiology is a scientific field that focuses on maintaining optimal functioning of an organism by regulating homeostasis. When there is an imbalance in homeostasis, it can lead to pathological conditions and potentially permanent diseases if left unaddressed. The body has a sensor network in place to detect even the slightest changes and intervene to maintain homeostasis. Modern technology allows for detection at the microsensor level, which further enhances our ability to monitor and regulate the body's functioning.

With advancements in technology, there is a growing trend to treat pathological conditions by mimicking the functioning of the human body, which is considered to be the most advanced organism. Nanotechnology has played a particularly significant role in the diagnosis and treatment of cancer, a widespread disease in our era.

In the 21st century, technological advancements are happening at such a rapid pace that it is difficult to keep up. While there are concerns that the constant influx of new technology may have harmful effects on human health, its undeniable benefits in the diagnosis and treatment of diseases have been proven, as seen during the recent Covid-19 pandemic that impacted the world. Vaccine technology is also evolving in parallel with current technological advancements.

Current technological research has made it possible to detect and treat potential diseases in fetuses. Studies are being conducted on cell and subcellular structures, thanks to microchip discoveries and developments at the nano and micro level. Promising research is being carried out against common conditions such as stem cell therapy, neurological diseases, Alzheimer's disease, and obesity.

Advancements in imaging system technologies have allowed us to better understand cellular interactions, and micro-surgery techniques are also a result of current technological development. Artificial intelligence and virtual reality research are gaining increasing significance in conjunction with neurophysiological studies.

1. Homeostasis

Homeostasis refers to the maintenance of a stable internal environment within the body. All tissues and organs are responsible for preserving this equilibrium. The human body monitors and processes a plethora of messages from both its own metabolism and the external environment through the nervous and endocrine systems. To generate appropriate responses, it receives and evaluates stimuli from control systems via a network of receptors and sensors. This intricate system allows the human body to function in harmony. The homeostatic mechanism, which involves positive and negative feedback, regulates the functioning of approximately 100 trillion cells. If the functioning of one group of cells is disrupted, all cells will eventually be affected. Mild dysfunctions can lead to pathological conditions, while severe ones can result in death.

The nervous system plays a crucial role in maintaining homeostasis by responding to sensations perceived by sensory receptors, either through the nervous or hormonal system. These sensory receptors allow the body to monitor its environment and respond accordingly,

- By mechanoreceptors mechanical pressure, tension,
- Changes in cold, heat and temperature by thermoreceptors,
- Physical or chemical damage to tissues by nociceptors,
- Light detected by electromagnetic receptors located on the retina of the eye,
- Chemoreceptors detect taste, smell, O_2/CO_2 concentration in arterial blood, osmolality in body fluids and other factors in body chemistry.

Biosensor structures have been created by merging analysis systems for biological substances, allowing for the detection of stimuli within living organisms. Essentially, the biological systems that living organisms use to sense and respond to changes in their environment have served as the foundation for biosensor development. When ligands are biological materials, these systems are referred to as biosensors in vivo.

In the laboratory, this sensing mechanism has been utilized to develop biosensors. Research has led to advances in microelectronics and the discovery of the remarkably sensitive responsiveness of biological structures, leading to rapid progress in biosensor technology. Biosensor technology has enabled the integration of molecular identification and most biochemical reactions with the capabilities of electronic and optical technology to enhance signal processing and transmission (Turner, 1989).

The definition of biosensors involves the combination of the selectivity of biological molecules or systems with the processing capability of modern electronic techniques, which draws from various scientific fields including biology, chemistry, biochemistry, and engineering (Spichiger-Keller, 1998). The history of biosensors dates back to the mid-1950s when L. C. Clark first measured glucose levels in the blood using biosensors. The biosensors developed by Clark and Lyons used oxygen as the electron acceptor, while later studies utilized redox mediators as electron acceptors (Telefoncu,1999).

Biosensors are devices that utilize the knowledge of various scientific fields such as biology, chemistry, biochemistry, and engineering. They combine the selectivity of biological molecules or systems with the processing power of modern electronic techniques. The history of biosensors dates back to the 1950s when L.C. Clark first measured glucose levels in the blood. While the biosensors developed by Clark and Lyons used oxygen as an electron acceptor, later studies utilized redox mediators as electron acceptors.

$$\text{Glucose} + O_2 \xrightarrow{\text{Glucose Oxidase}} \text{Gluconic acid} + H_2O_2$$

$$\text{Glucose Oxidase-FADH}_2 + M_{ox} \longleftrightarrow \text{Glucose Oxidase-FAD} + M_{red} + 2H_2$$

$$M_{ox} = M_{red} = \text{redox mediator}$$

The third generation of biosensors achieves direct electrical communication between the enzyme's redox center and the electrode surface, eliminating the need for redox mediators (Telefoncu,1999).

2. Structure and Function of Biosensors

Biosensors consist of biocomponents (receptor) and physical components (transducer). The working principle of the biosensor is schematized in Table 1.

Table 1

Structure and Working Principle of Biosensors

	Biocomponents	Converters		
Example	-Texture - Microorganism - Cell - Organel - Immuno agent - Hormone - Enzyme - Nucleic acid - Synthetic biore-ceptor	- Physical sensing -- Electrochemical methods Potentiometric Amperometric Thermometric Conductometric Impedimetric -- Piezoelectric -- Optics - Chemical detection	Signal booster	Data acquisition, evaluation

a. Biocomponents

Enzymes and antibodies are frequently used as bioreceptors in the structure of biosensors. Biocomponents, also known as bioreceptors, in biosensors include enzymes, antibodies, nucleic acids, chemical receptors embedded in biological membranes, microorganisms, organelles, and tissue sections. These bioreceptors transform the substance being analyzed, and the changes that occur are detected by the transducer. Enzymes are commonly used due to their high specificity, while cell systems and microorganisms are used when suitable enzymes are not available or when multiple substances need to be determined. Microorganisms are useful in biological oxygen demand, toxicity, and mutagenicity tests because they exhibit different receptor behaviors. Biosensors are devices that convert biochemical responses into physical, chemical, or electrical signals, with bioreceptors recognizing the analyte and transducers converting the chemical or physical signal produced into electrical signals (Telefoncu,1999).

b. Transducers

Transducers convert the biological reaction of receptors into a measurable physical signal. The transducer is selected according to the biochemical reaction. Electrodes are used in amperometric and potentiometric measurements, where the target is the analyte. In optical sensors the target is light and in piezoelectric sensors the target is the change in the oscillation resonance of the crystal due to mass loading (Grattarola & Massobrio 1998).

The classifications of biosensors are based on various factors, such as the type of transducer or the reaction they undergo. One of the most common classifications is based on whether the biosensor undergoes a physical or chemical reaction.

A. Physical sensing

Physical sensing involves converting the signal generated by the reaction between the biosensor and the analyte into an electrical signal. This conversion occurs due to changes in physical quantities by the transducer.

A.1. Electrochemical Biosensors

The detection and quantification of foodborne pathogens can be achieved using electrochemical biosensors. Various types of electrochemical biosensors exist, which measure changes in current, impedance, voltage, and conductivity that result from the interactions between antigens and bioreceptors.

A.1.1. Amperometric Biosensors

In 1956, Clark began research on amperometric biosensors using oxygen electrodes, which paved the way for further developments in this field. Among the various electrochemical detection methods used for pathogen detection, amperometric biosensors are the most commonly used. The signal of these biosensors is produced by the exchange of electrons between the biological system in the bioreceptor layer and the electrode.

Clark initiated research in the field of amperometric biosensors in 1956 using oxygen electrodes. These biosensors are widely used for pathogen detection and employ electron exchange between the biological system and the electrode in the bioreceptor layer to generate a signal. Several researchers have reported the successful detection of foodborne pathogens, including *E. coli O157:H7*, using amperometric biosensors (Abdel-Hamid et al., 1999. Chemburu et al., 2005).

A.1.2. Potentiometric Biosensors

Potentiometric biosensors are a type of electrochemical biosensors that operate at a constant current. Potentiometry is the measurement of the potential difference between a working electrode and a reference electrode. The reference electrode has a constant voltage value and is not affected by its environment, while the measuring electrode represents the voltage value resulting from the reduction and oxidation reactions that occur on solid and liquid surfaces (Grattarola & Massobrio, 1998). Glass electrodes sensitive to pH or monovalent ions, ion-selective electrodes sensitive to anions or cations, and gas-sensitive electrodes such as CO_2 or NH_3 are commonly used in potentiometric biosensors. Among these, field effect-based potentiometric sensors are preferred due to their high pH sensitivity (Wagner et al., 2012). Photosensitive potentiometric sensors have also been utilized for detecting *E. coli* cells in vegetable foods (Ercole et al., 2003).

A.1.3. Thermometric Biosensors

Thermal biosensors, also called calorimetric biosensors, are developed by combining the biomaterial with a physical transducer such as a thermometer. Thermal-based calorimetric biosensors can be used in enzyme activity measurements, clinical monitoring, process control, water-free environment measurements and environmental monitoring by monitoring the temperature changes that occur (Yakovleva et al., 2013).

A.1.4. Conductometric (Conductivity) Biosensors

The ability of an analyte under investigation to conduct an electric current between electrodes is measured by conductometric devices. Due to the externally applied current, ion mobility occurs between the two electrodes. Conductometric biosensors measure this ion mobility. Devices based on conductometry can be employed to investigate enzymatic reactions that lead to alterations in the concentration of charged species present in a solution.

A.1.5. Impedimetric Biosensors

It is created by immobilization of biological recognition elements on an electrode surface. The electrical impedance signal generated by the analyte at the output is measured or monitored and the result report is generated (Dinçkaya, 1999).

A.2. Optical Biosensors

Due to their sensitivity and selectivity, optical biosensors have become increasingly popular for the detection of bacterial pathogens. These biosensors operate by measuring the light absorbed or emitted during a biochemical reaction. Biotransduction elements such as enzymes, antibodies, antigens, nucleic acids, whole cells, and tissues can be employed in optical biosensors.

A.2.1. Biosensors Based on Surface Plasmon Resonance (SPR)

SPR is a straightforward and direct method that detects the alteration in the refractive index adjacent to a metallic surface. In this type of biosensor, light from a light-emitting diode (LED) reflects off a gold surface, and the angle and intensity associated with the minimum SPR are evaluated.

A.2.2. Optical Fiber Biosensors

Fiber optic biosensors rely on tapered fibers to deliver laser light for exciting the sensing surface and detect the emitted light. Light traveling through a fiber or waveguide can be highly sensitive to changes in its surroundings, which makes optical fibers a great candidate for various food applications, including pathogen detection and identification. For instance, Simpson and colleagues employed optical fiber biosensors in conjunction with other optical techniques to detect foodborne pathogens like *Listeria, Salmonella, E. coli* and *Clostridium botulinum* (Simpson and LimRapid, 2005).

A.3. Piezoelectric Biosensors

Piezoelectricity refers to the phenomenon where certain materials produce electric charge when subjected to mechanical stress or deformation. The word "piezein" from ancient Greek, meaning pressure, inspired the term. The study of piezoelectricity originated from crystal physics and was pioneered by Jacques Curie and Pierre Curie. In 1880, Pierre and Jacques Curie discovered that several crystals, such as quartz, tourmaline, and sugar cane, exhibit piezoelectric properties (Curie and Curie, 1880).

Piezoelectric devices were first used as a major breakthrough during World War 1. The development of a tool for locating sunken transport ships required the use of these devices. Physicist Paul Langevin, who was involved in the work, invented an ultrasonic submarine detection technique in 1918 that utilized a quartz-based piezoelectric transducer. This technique, called sonar, later proved valuable in World War II. Langevin's discovery created opportunities for further research on piezoelectricity, including ultrasonic transducers, microphones, and accelerometers. Materials with these properties are utilized in sensors, temperature regulators, nonlinear capacitors, electromagnetic radiation receivers, and devices that operate in a frequency range from radio waves to visible light.

A sensor is a device that transforms physical or chemical quantities, such as temperature, humidity, sound, pressure, force, distance, acceleration and pH, into electrical signals. Piezoelectric sensors are a type of device that utilizes the piezoelectric effect to detect variations in pressure and acceleration and convert them into electrical signals. By converting mechanical energy into electrical energy, these sensors are able to carry out their functions.

Piezoelectric transducers have led to the development of various devices such as ultrasonic delay lines, ultrasonic medical diagnostic and treatment devices, and industrial control sensors for physical and chemical substances. Furthermore, advancements in electroacoustic transducers have made piezoelectric transducers more efficient. These transducers are now used in different industries, such as ultrasonic tomography, pulse measurements, tone measurements, urology, ophthalmology, medicine and bioengineering. Piezoelectric transducers can be found in numerous applications, including airbag sensors in automobiles, disk drives in computers, and ultrasonic imaging systems in medical fields.

A.3.1. Quartz Crystal Microbalance

The Quartz Crystal Microbalance (QCM) is a detection platform based on piezoelectricity and is utilized for clinical applications. It operates by measuring the changes in resonance frequency (Δf) that occur due to analytes binding to the sensor surface. QCMs are commercially available devices.

QCM applications and studies with piezoelectric sensors

Due to their various advantages, QCM systems can be applied in multiple sectors such as the cheap and small size of the recognizer section, ease of use, the ability to work with very small concentrations of samples, specificity, on-site measurement, repeatability and high sensitivity. Especially recently, the use of QCM systems has increased considerably. Some of the areas of use are listed below.

- Biotechnology
- Biocompatibility of surfaces
- The binding of complementary sequences of DNA and RNA
- Detection of bacteria, viruses, mammalian cells
- By immobilized receptors
- Recognition of protein ligands
- Pharmaceutical research
- In the distribution of the drug
- Melting polymer coatings
- Interaction of drugs at a molecular level

- Electrode surfaces
- Electrochemistry of interfacial processes
- Functionalized surfaces
- Lipid membranes
- Polymer coatings
- Thin film formation
- Reactive surfaces
- Gas sensors

B. Chemical sensing:

Some biosensors use transformation reactions or binding reactions to identify structures in the analyte. Conversion reactions involve using an enzyme as a bioreceptor to convert the component being analyzed into a detectable product through a transducer. An instance of this is the transformation of penicillin into penicillic acid via the penicillinase enzyme. In this structure, a pH electrode is then used for measurement. Binding reactions are a special detection method based on antibody-antigen association reactions. The change in electrical charge, mass or optical properties that occurs after the reaction is detected by the types of transducers described above.

Another way to classify biosensors is based on their transducer's working principle. In this case,

- In biocatalytic sensors, enzymes, microorganisms and tissue elements used as receptors interact catalytically with the molecule to be analyzed.
- In bioaffinity sensors, molecular sensing is performed by antibodies, receptors or immobilized proteins.
- Another way to classify biosensors is based on their application or use. These are,
- Disposable: used to measure the amount of glucose in the blood
- Intermediate-use: nM-sized measurements are performed under laboratory conditions.
- Continuous use: in the form of biosensors.

3. Application Areas of Biosensors

Biosensors play a crucial role in medicine, agriculture, food, pharmacy, environmental pollution, defense and many industrial activities, especially in automation, quality control, energy extraction and condition detection. To date, sensors have been prepared for more than 180 different substances, of which only about 25 are commercially available. Possible application areas for biosensors:

- Clinical diagnostics, biomedical
- Process control
- Bioreactor control

- Food production and analysis
- Agriculture and veterinary medicine
- Diagnosis of bacteria and viruses
- Drug analysis
- Industrial wastewater control
- Environmental protection and pollution control
- Toxic gas analysis in mining enterprises
- Military applications.

The biomedical industry is recognized as the most promising market for biosensors. Enzyme sensors were among the first biosensors utilized in this field, and the glucose oxidase electrode was the first biosensor to be commercially produced. This biosensor facilitated the detection of glucose in blood and urine, which is crucial for the diagnosis of diabetes.

In biotechnology and food industry, enzyme sensors are employed for detecting or measuring glucose levels, many monosaccharides, amino acids, organic acids (lactic acid) urea and alcohol. In addition, biosensors can be prepared for complex parameters such as aroma and freshness as well as foreign substances in foods (pesticides, toxins and foreign hormones, etc.).

Biosensors are expected to play a role in combating drug abuse and addiction. Biosensors can replace drug-seeking dogs. This will save time especially at customs and police stations. Microbial sensors and enzyme sensors are used to control soil, air and water pollution.

Urea and creatinine electrodes, cholesterol electrodes, acetylcholine electrodes are also examples of medical biosensors. These sensors can be used to diagnose very important diseases. For example, urea levels are used to monitor kidney function, cholesterol levels are used to prevent arteriosclerosis, and acetylcholine electrodes are used to assess muscle fatigue (Rainina et al., 1996)

Due to the high specificity of immunological reactions, immunological biosensors are very suitable for use in medicine. These sensors are widely used in the measurement of drug active substances. For example, theophylline sensor, HCG hormone sensor for pregnancy testing, alpha-fetoprotein sensor for cancer diagnosis, surface antigen sensor for hepatitis B are immunological sensors used in medicine (McGlennen RC, 2001).

Biosensors implanted in prostheses detect the types of bacteria growing on the surface of the prosthesis, and antibacterial agents in the prosthesis are secreted to prevent infection (D'Souza, 2001).

3.1. Nanotechnology and biochips

Nowadays, a new generation of biosensors, called modern-day biosensors, are being developed using nanotechnology or chip technology. These biosensors make it possible to monitor and evaluate the results more easily. When a biochip is implanted into an object using advanced technologies, it is possible to follow the changes that occur during the detection phase without the need to go to the hospital. For example, thanks to advances in nucleotide amplification and imaging techniques in nanotechnology, nucleotide-based biosensors are now widely used (Noh et al.,2011 and Arlett et al., 2011).

Biosensors have various applications in the biomedical field, and one of the most significant ones is the measurement of blood glucose levels in diabetic patients, gene analysis, regulating heart rhythms in chronic heart disease patients (peacemaker), analyzing antibodies produced as a result of allergic reactions, repairing damaged tissue or bone, monitoring metabolic products and monitoring patients undergoing dialysis treatment. In addition, so-called 'lab-on-a-chip' systems such as in vivo pressure sensors, implantable microelectrode arrays, drug delivery systems and biochemical sensors have been produced.

Glucose, cholesterol, lactate, urea, creatine biosensors in biomedical use are amperometric biosensors. They are used 'off line', 'in vivo' or 'on line'. Off line detectors determine the concentration of the analyte by injecting it into the environment to be measured (such as the human body). Glucose biosensors belong to this class. In in vivo applications, the biosensor is implanted into the body so that the relevant concentration of the analyte under investigation is continuously read. In on-line applications, the biosensor is connected to the flow line of the sample in the body.

DNA biosensors used in gene analysis provide important data in clinical and forensic investigations such as the determination of DNA-drug interactions, infectious and hereditary diseases.

Rapid progress is being made in the production of micro and nano-sized sensors. In particular, bio-micro and bio-nano electromechanical systems (BioMEMS/BioNEMS), which emerged with the application of micro and nano electromechanical system (MEMS/NEMS) technologies to biosensors, have enabled the creation of sensor systems where highly sensitive measurements can be made, especially in in vivo applications. The utilization of nanomaterials for biosensor production offers notable enhancements in properties like sensitivity, measurement range, and speed.

With biochips, chemical separations can be performed, as well as many processes such as clinical analysis, DNA analysis, protein analysis, synthesis and analysis of chemical substances, detection of toxic structures (Borsting et al., 2004).

Biochip technology enables the performance of thousands of gene assays, with the goal of monitoring the entire genome on a single chip and determining interactions. This technology is based on biosensor structures and utilizes the infrastructure of previous biosensor studies. The clinical use of DNA microchips in small-sized devices began with a licensed company in the United States, marking the first steps in the clinical application of biochip technology (Liu et al., 1996).

Some examples of BioMEMS applications include the use of excitatory neural implants, retinal implants for the treatment of blindness, and microneedles for painless vaccination (Grayson et al., 2004).

3.2. Biomarker in cancer

Biomarkers are quantifiable molecules, including DNA, RNA, proteins and metabolites, present in body fluids at an abnormal level that signal a pathological condition such as cancer. A biomarker is a substance that can be indicative of the presence of cancer, such as a molecule secreted by a malignant tumor or a distinctive response of the body to cancer. All types of cancer and their progression through different stages of development have been linked to changes in gene sequence or expression, as well as protein structure and function. Changes in gene and protein expression or modification are employed to detect cancer, determine prognosis, monitor disease progression, and evaluate therapeutic response (Rasooly & James, 2006).

The human body operates various metabolic pathways to maintain homeostasis, a state of equilibrium. In cases of carcinogenesis, this balance is disturbed and some of the regulatory systems in our body stop working. In such cases, the following biological molecules in tissues may be candidate biomarkers;

- DNA
- RNA
- Proteins
- Enzymes
- Metabolites
- Hormones
- Receptors
- Carbohydrates.

These biological molecules are used as biomarkers depending on the changes in their structure, their increase, decrease and the responses they receive. The following Table 2 lists some of the molecules used as cancer biomarkers (Tothill, 2009).

Biomarker Name	Cancer Type
AFP	Liver cancer
BCR-ABL	Chronic marrow leukemia
BRCA1/BRCA2	Breast, Ovarian Cancer
BRAF V600E	Skin, Colon Cancer
CA-125	Ovarian Cancer
CA 19.9	Pancreatic Cancer
CEA	Colon Cancer
EGFR	Non-small cell lung cancer
HER-2	Breast cancer
KIT	Digestive tract stromal cancer
PSA	Prostate Cancer
S100	Skin cancer
VEGF	Breast Cancer

The analytical methods used for detecting these molecules rely on the recognition of specific antibodies and antigens, which trigger an immune response. Characteristics of a biomarker:

- Its accuracy must be constant during the disease.
- High sensitivity.

- It should have high specificity, the margin of error should be minimized.
- It should give a definite response in early diagnosis.
- It should be decisive without the need for complicated medical procedures.
- An economical screening method is also desirable for selecting biomarkers. A biomarker that possesses these qualities can be utilized in medical settings and in vitro experiments (Bahadir & Sezginturk, 2015).

3.3. Importanceof Early Diagnosis

Early diagnosis of diseases is crucial in determining the effectiveness of the treatment. The timely identification of diseases can delay the onset of severe symptoms, reduce their severity or prevent the disease from progressing to an incurable stage. However, certain diseases may exhibit symptoms only in their advanced stages, making it difficult to diagnose the disease at an early stage.

Biomarkers, which are biological indicators, play a crucial role in the early detection and diagnosis of diseases by helping to determine the presence and stage of the disease.

Antibodies or antigens in antibody-antigen interaction, nucleic acids (DNA, RNA) in nucleic acid-nucleic acid interaction or proteins in protein-protein interaction are called biomarkers. Biomarkers can be present in various body tissues like skin, hair, and nails, as well as in body fluids such as blood, urine, saliva, and cerebrospinal fluid. Although the importance of molecular diagnostics has increased in clinical practice in recent years, the lack of disease-specific biomarkers has limited molecular diagnostics (Wagner, 2004).

The serum components of saliva are derived from the local vascular network connected to the carotid artery. Hence, saliva is a rich source of fluids containing a multitude of molecules present in the systemic circulation, which can be utilized for the early detection of various diseases (Wong et al., 2003).

Saliva contains proteins and genetic molecules such as DNA and RNA. The fact that the analysis tests performed with saliva, which is similar to blood in terms of content, are cheap, easy and reliable reveals the importance of saliva biomarkers in the diagnosis of diseases. Saliva as diagnostic material:

- Hormonal diseases,
- Cardiovascular diseases,
- Infectious diseases (bacterial/viral),
- Oncologic diseases,
- Kidney diseases,
- Autoimmune diseases,
- It is used to detect drug addictions and drug use.

When saliva diagnostic methods become widespread in the future, effective screening programs can be carried out in regions with low socioeconomic status, and the health level of the society can be increased by identifying and treating patients in the risk group (Kocík et al., 2007 and Pink et al., 2009).

In the near future, with the development of electrobiochemical analysis methods, expensive and space-consuming laboratory devices will be replaced by compact biosensor systems (Mugweru, 2007 and Kökbaş et al., 2013). In the R&D studies conducted after the COVID-19 pandemic, determination can be made with IgG biosensor. Covid-19 biosensors can measure in all body fluids. It is a method that has the reliability of Rt-PCR and the speed of rapid diagnostic tests (Harun-Ur-Rashid et L., 2022 and Parihar et al., 2020).

The prolongation of the life span in advanced industrial societies brings new problems. Neurodegenerative diseases such as Alzheimer's, Parkinson's, and Huntington's diseases, which have the highest mortality rate with advancing age, are caused by inflammation. Tumor necrosis factor is a glycoprotein cytokine secreted by many cells. It is known that TNF alpha levels increase in aging and neurodegenerative diseases due to decreased innate immune protection. Based on this point, biosensors are being developed for the early diagnosis of TNF alpha.

In summary, biosensors are cost-effective and easy-to-use devices that provide high sensitivity and rapid response time, making them valuable tools in various fields, including healthcare and environmental monitoring. As technology advances, wireless biosensors are increasingly being developed and employed for patient diagnosis and monitoring, particularly in the healthcare sector. Therefore, the design of different biosensors and the use of these biosensors are important. In the 50s, Clark and Lyons determined glucose in vitro. In recent years, wireless biosensors suitable for in vivo use have been designed. Nowadays, in vitro biosensors are being designed that get their energy from blood pumping, chemical changes in the body, breathing or body movements. Thanks to the microchips implanted in the body, the data transferred to the electronic environment (cell phone, computer, etc.) can be utilized to detect the component to be quantified in the body. Wireless biosensors are rapidly developing, continuous and wearable biosensors connected to network networks. For these reasons, wireless biosensors provide convenience in monitoring disease markers in the hospital environment or in daily life (Keskin & Arslan, 2020).

As long as homeostasis is maintained, the organism continues to exist in a healthy way. Biotechnological developments continue to develop and promise through biosensor mechanisms together with medical technology to ensure and maintain homeostasis.

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To Cite This Chapter:
Taki, F.N. (2023). Biosensor Technologies in the Context of Medical Physiology. In S.N. Guner, Y. Uzun & I. Cetin (Eds.), *Current Studies in Healthcare and Technology* (pp. 153-168). ISRES Publishing.

CHAPTER 13

Use Of Digital Technology In Health Care For Children

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USE OF DIGITAL TECHNOLOGY IN HEALTH CARE FOR CHILDREN

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Introduction

With the development of technology and industry, a new era, dubbed the "digital age," has begun. All sectors and fields have been affected by this new era, and traditional practices have been replaced by technology-supported applications. Thus, information exchange and communication between people have accelerated. These developments have also found their place in the field of health, as in other fields. Technology development has created opportunities for patients. With the support of technology added to modern diagnosis and treatment methods, these applications have become easier and more accessible. With digital health technology, the traditional health system has been replaced by a technology-supported health system. It is expected that this situation will completely change the methods of health service delivery in the future. New tools and technologies are initiating a digital transformation in all health systems around the world. This technology provides high efficiency in clinical practices, reduces, or prevents complications and adverse events, prevents patients from experiencing socioeconomic problems, improves people's quality of life, and organizes the working lives of health professionals.

1. Digital health technology

"A phenomenon that allows data, text, and images to be transferred, stored, collected, and displayed over a single infrastructure" is the definition of the term "digitalization." Health services have been affected by the digital change that affects every part of life. A new era has started, especially with the use of digital technologies in health services (Ekinci et al., 2021). Health technology advancements can enable people to get medical treatment conveniently and comfortably at any time and from any location. The basis for this is that people lead a healthy, high-quality, and prosperous life. Today, owing to digital technology, information is much more accessible. A database may be used to store and access digital medical records from any location. As a result of this, healthcare professionals can gather patient information more quickly (Simsir & Mete, 2002). Patients now have more convenient and rapid access to health knowledge and assistance, no matter where they are. The care recipient and the caregiver do not need to be prepared at the same time when using digital health. Additionally, this implies that countries that have limited access to healthcare services might deliver necessary treatment much more quickly and easily. This technology benefits both the caregiver and the care recipient, as well as the nation's health system and economy (Simsir & Mete, 2021).

1.1. Definition

Digital health refers to the use of information and communication technology for patient diagnosis and care, risk assessment of healthy people, training of healthcare professionals, and observing and improving public health. Individuals can profit from digital health, but it also has a big impact on the delivery of modern, effective, and high-quality Healthcare (Uysal & Ulusinan, 2020).

1.2. Etiology

The beginning of digital health is the availability of accurate, current, and reliable medical data. By actively utilizing the appropriate health technology and health literacy, people could do this.

Accurate, quick, and efficient information may be given to health professionals with regards to occupational training, health promotion, illness healing, and rehabilitation techniques (Haupeltshofer et al., 2020). With the digitization of documents, the increase in computer speed, the development of cloud-based services, the advancement of mobile technology, and the widespread use of other portable digital devices, digitization is advancing rapidly (Temur and Aksoy, 2022; Gopal et al., 2019; Tezcan, 2016).

1.3. Digital health in the world

The digital world is still seeing technological advancements and changes from the past to the present. And the rate of progress is going to increase in the years to come (Kuyucu, 2017). The market for digital health technology is a developing field that welcomes further investment. This is why investors naturally gravitate toward this field, particularly top internet-supported businesses (Kuh and Erdem, 2021). The World Health Organization actively contributes to the accessibility of digital health services and health information. In this regard, the Global Digital Health Strategy (2020-2025) was developed to accelerate the acceptance and development of digital health apps as well as to improve the health of all people, regardless of age.

The goal is to strengthen the digital health industry in this manner and better represent it to the public. Solutions are provided for a variety of issues with digital health, including monitoring health parameters, being aware of one's own health status, disease diagnosis, treatment, and post-treatment services; online appointments; simple access to appropriate information; asking questions without wasting time; and decreasing possible mistakes.

1.4. Digital health in Turkey

There has been a significant information revolution as a result of the quick development and adoption of technology in the latter part of the 20th century. In Turkey, experiments with digitization in the medical field began in the middle of the 1960s. However, until the 2000s, there had been little real development (Vermisli Peker et al., 2018). Within the framework of the "Health Transformation Program," which was started by the Ministry of Health in 2003, several digital health apps have been activated (Cavmak & Cavmak, 2017; Gumus & Cetin, 2022). Today, these applications are becoming more common. Numerous alternative methods have been employed in the continuous quest to move healthcare toward digitalization. At the same time, the mobile apps division of the Ministry of Health in Turkey worked to organize the nation's healthcare system with a new digital infrastructure.

Applications including SaglıkNet, e-nabız, the family medicine information system, telemedicine, electronic health records, the national medical rescue team, and the central scheduling system for doctors have all been put in place (Bayrak & Dalkiran, 2022; Ministry of Health, 2019).

1.5. Tools for digital health

Today, diagnosis and treatment are carried out considerably more quickly owing to technology in the field of health, where information technologies are employed most frequently (Leblalta et al., 2022, 2021). The use of information and communication technology in electronic health, health-related services, and procedures is referred to as "e-health" (electronic health) or "digital health” (Krey et al., 2019). The term "digital health care," which has gained significant importance for contemporary health systems around the world, encompasses a wide range of scientific concepts and technologies, including artificial intelligence, 3D printers, wearable health technologies, integrated data systems, telehealth, and mobile health (Ozen, 2021; Sultan, 2015).

1.5.1. Telehealth

To enable clinicians to provide medical treatment remotely, telemedicine enables clinical services to take advantage of information technology, visual imaging, and telecommunications connectivity. The delivery of medical services remotely by a physician is not the only definition of telehealth. It also includes telemedicine, teleeducation, telenursing, and telepharmacy services offered by anyone other than healthcare providers. Looking more closely at these concepts reveals that, under telehealth, patients and healthcare professionals are not physically present in the same place and that healthcare services are supported digitally (Ozen, 2021; Uysal & Ulusinan, 2020)

1.5.2. 3D Printers

3D printers have been around since the 1980s, when computers first became widely used. Their application to health, however, is recent. Despite being new, it has a wide range of uses in healthcare. In many sectors of health, printing technology is favored because it can generate products that are personalized or meet specific requirements. The main applications in the field of health include the production of tissues and organs, orthoses, prostheses, and implants; surgical planning; radiological programs; hearing aids; dental prostheses; and tools that guard against life-threatening infectious diseases like AIDS, as well as pharmacological applications, educational applications, and the production of surgical instruments (Uysal & Ulusinan, 2020).

1.5.3. Integrated regional and national and international health communication networks

With the use of computers, health information programs, and information processing and transmission technologies, health telematics enables us to share and transfer health information. Health informatics are used in telehealth to provide services remotely. By ensuring continuity across the nation, health informatics attempts to deliver all required healthcare services in the most practical, efficient, and affordable manner possible. Every day, there has to be a huge interchange of information between health institutions and the people in charge in order to assure continuity (Erkilic &Yalcin, 2020).

Health information networks on a national and worldwide level are developing. They make it easier for both healthy and ill individuals to move around and access information, as well as for healthcare professionals to share that information (Long et al., 2018). Health services become more effective and of higher quality as a result. The health information network's goal is to provide access to health information and communication services as well as communication and storage methods for use by health applications, professionals, and the public. Additionally, it offers services like a network for health information, data security and privacy, load balancing, service quality and continuity, integration, development and enhancement of health information resources, and support for workflow (Erkilic &Yalcin, 2020; Long et al., 2018; Health Ministry, 2019; Avci & Avsar, 2016; Uysal & Ulusinan, 2020).

1.5.4. Mobil health

Mobile devices can use all of the telehealth services, and the term "mobile health" is used to refer to telemedicine as well (Tezcan, 2016). Online resources and mobile applications have started to play a significant role for users as healthcare services have become more digital (Ekinci et al., 2021). A more recent concept, mobile health refers to services supported by transportable communication devices such as smartphones, tablets, personal digital assistants, and wireless patient monitoring (Long et al., 2018). A wide range of smartphone applications, from telemedicine programs to pharmacy programs, fall under the heading of "mobile healthcare" (Ozen, 2021). Applications for mobile health may track vital signs, eating habits, health and disease features, and daily activities like exercise. Additionally, by delivering individualized recommendations for healthy lifestyles, mobile applications offer personalized solutions (Uysal & Ulusinan, 2020).

1.5.5. Wearable health technologies

Devices and computers that may be readily worn on the body and incorporated into clothes and other items are known as wearable technology (Sultan, 2015). The primary advantage of the devices is that they can perform many of the same essential tasks as computers and cell phones and, in some cases, exceed them. People may rapidly obtain information utilizing this technology via the internet. Health is the most significant application area for wearable technology (Erkilic & Yalcin, 2020). Wearable technologies, which have gained a lot of appeal in the healthcare industry, enable patients to remotely check their health condition and communicate their data to the physician without needing to go to a hospital. By continuously tracking health and illness data, bigger issues that can develop with early intervention might be avoided. As a result, unnecessary processes are avoided, which lowers expenses and raises the standard of healthcare (Uysal & Ulusinan, 2020).

By gathering data and collecting information about human health, wearable health devices not only help improve health status but also help advance health technology (Lou et al., 2020; Erkilic & Yalcin, 2020).

1.5.6. Digital self-tracking technologies

Remote patient monitoring using information technology is also gaining popularity.

Digital self-monitoring technologies are quickly spreading throughout Turkey as a result of improvements in health technology (Leblalta et al., 2022). The usage of digital self-tracking devices is rapidly expanding throughout Turkey and the rest of the world as a reflection of technical advancements and the digitization of the health sector. These technologies are frequently employed in the monitoring and treatment of chronic illnesses (Leblalta et al., 2022; Morgan, 2016). Remote patient monitoring using information technology is also gaining popularity. These technologies are exceptional for analyzing changes in the connection between technology and the body.

1.5.7. Big data management and artificial intelligence

New technologies have evolved as a result of the unique characteristics of human intellect and the growth of intelligence. Artificial intelligence is among them. Artificial intelligence is now widely used in a variety of fields, including computers, mobile phones, the automobile industry, and the industrial sector. Artificial intelligence is commonly defined as information processing systems that resemble human intelligence-related activities such as learning, reasoning, adaptability, and interaction. Applications of artificial intelligence are utilized or tested for a variety of health service delivery and research objectives, including illness diagnosis, chronic disease management, and the provision of health care (Uysal & Ulusinan, 2020).

1.5.8. Health-related digital games

Digital health games are acknowledged as an original and successful approach for promoting public health and raising awareness of health literacy. While health games provide users with entertaining advice for leading healthy lives, they also impart fundamental knowledge about how the human body functions. In this context, health games may be utilized as an additional instrument for a variety of purposes, including enhancing the quality of life, rehabilitation, learning about various diseases, and learning how to treat them. One method of promoting digital health is through games (Avci & Avsar, 2016).

1.6. Consequences of Using Digital Health Technology

Digitization is in every aspect of life today. Health services that include digital technology and will be available globally are now being developed and are improving daily. Patients are no longer limited by time or place thanks to this adaptable healthcare system. Basic characteristics include self-care, social support, integrated care, self-monitoring of health outcomes, and quick remote intervention. Numerous potentials exist to influence primary healthcare's future and make successful public health initiatives possible thanks to digital technologies. They accelerate the change to digital health education, practices, and policies.

Numerous potentials exist to influence primary healthcare's future and make successful public health initiatives possible thanks to digital technologies. They propel a change in digital health education, practices, and policies. A number of significant steps have been taken toward reducing the complexity of health services as a result of the digitalization of hospital applications and health services. These include shorter patient wait times and fewer stays in the hospital, the replacement of paper documents and file stacks with digital formats, and interactive staff-patient communication. Being unable to visit the hospital owing to distance or other issues is no longer a concern thanks to digital health applications. Exams, interviews, and interactions between patients and medical personnel are now given in an ideal and efficient manner (Ozen, 2021; Long et al., 2018).

2. Childhood and digital health technology

Digital health technology is generally defined as the use of technology in the promotion, prevention, treatment and maintenance of health and health services Mobile health (mHealth), health information technology (IT), text messaging, applications, wearable devices, telehealth and telemedicine, digital gaming, virtual reality, robotics, online support groups and social networks are digital health technology applications used during childhood. This technology can be used in a variety of ways, such as information presentation, two-way communication, or long-term assessment (Cheng et al. 2020; Devine et. al 2018).

Wearable or small sensors used in children are a constant source of data. Children who do not have to go to the hospital for a checkup will not be absent from school. In addition, the working parent does not have to take time off to take the child to the hospital, saving time and money (Sacks et al. 2022).

2.1. Advantages and disadvantages of using digital health technology according to childhood periods

After the Covid 19 pandemic, telehealth applications have increased all over the world. Thanks to the interviews made by videoconference, patients from long distances were reached. In addition, health professionals communicated with each other more easily and exchanged information. Telehealth has positive aspects as well as disadvantages. There are some concerns about security. In addition, the presence of face-to-face communication negatively affects interpersonal relations. Participants need technical support and devices such as computers and phones(Devine et al. 2018).

With the widespread use of digital health in recent years, children and adolescents were exposed to digital stimuli at a young age. Smartphones and tablets have become the most preferred "toys" for children in development. The effects of digital devices on sleep, vision, hearing, metabolic functions, parent-child relationships and emotional development have been observed (Pisano et al., 2022).

2.2. Healthy child and digital health technology

Digital technologies may suggest that they reduce children's activities. However, if used correctly and appropriately, they have many benefits. For example, digital tools such as gaming consoles, smartphones and social media can be useful to promote physical activity. They organize children's free time. They can provide stimulating methods for getting activities and peer support with fitness programs and daily goal reminders. In particular, gamification can improve user experiences and motivate children to participate in physical activity. Developing creative ways to engage children and adolescents in physical activity may include participating in online physical education classes or playing physically active games. Social media can support children and their families to participate in sports such as running, biking, swimming. Smart watches and other devices send instant notifications with functions such as counting steps and measuring heart rate, and thus encourage increasing physical activity (Malizia et al. 2021; Riley et al 2018).

3. Sick child and digital health technology

Digital health technology is used in the treatment of many diseases such as diabetes, oncology, anxiety disorders in children.In children with oncological disease, virtual reality is generally used to relieve pain and alleviate symptom distress associated with treatments such as chemotherapy (Cheng et al 2020). Digital health technology also has an effect on anxiety. Virtual reality, web-based technology and a humanoid robot are used to reduce anxiety (Cheng et al 2020).

In diabetic children, digital tools are also used to educate children and to monitor their own diseases and treatments. Various new channels have been found for patient education and communication. Personalized robots for diabetes education and daily use have become more affordable and acceptable for management. Applications integrated into the camera of mobile phones are used to determine the carbohydrate content of foods and to demonstrate correct injection techniques. Wearable devices with cameras are being developed that can be used to assess dietary intake and can interact with deep-learning computer techniques for sleep quality evaluation (Fernandez-Luque 2021).

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Smilarity Index:
The similarity index obtained from the plagiarism software for this book chapter is %13.

To Cite This Chapter:
Ar, I. & Şimşek, A. (2023). Use Of Digital Technology. In Health Care For Children: Artificial Intelligence Interventions. In S.N. Guner, Y. Uzun & I. Cetin (Eds.), *Current Studies in Healthcare and Technology* (pp.169–179). ISRES Publishing.

CHAPTER 14

The Use of Technology in Health Research

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The Use of Technology in Health Research

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Introduction

Healthcare services are a multidisciplinary set of processes that aim to maintain a person's quality of life at the highest level through disease prevention, treatment, care during illness, ensuring continuity of care, and regular monitoring. The impact of developments in science and technology on the delivery of health services is inevitable. Technology has made significant contributions, such as the creation of home monitoring and tracking systems, during the pandemic process. Treatment and care practices and research that involve innovation and the use of technology in healthcare will pave the way for quality service delivery and improved patient outcomes. The aim of this section is to highlight the current trends in health research, research examples, and the development of innovative products and useful models.

The Aim of Using Technology in Health Research

"Technology" refers to the knowledge encompassing production methods, tools, equipment, and materials used in a particular industry. It is also a term that includes all the information for the production of useful products and the design of new ones. The existence of technology can be seen in the form of new products, machines, vehicles, materials, and services. The use of technology allows science to meet the practical needs of daily life. It facilitates applications for shaping and controlling the environment. Technology helps to provide higher standards of living through increased productivity and a wider range of products. Scientific research aimed at developing new technology and the transformation of research into new products are intertwined and successive processes (Emiroglu, 2018).

Health technology is the collection of innovations and technologies that include versatile systems, philosophies, methods, applications, and other techniques used for preventive and curative healthcare services. These technologies are not only limited to the use of advanced technologies but also encompass drug and medical technologies. It is stated that both categories are affected by developments in science and technology (Sargutan 2005).

Health services are integrated with technology. Wearable technologies, especially those used for fitness and heart rate monitoring, are actively used in the monitoring of chronic diseases. The development of artificial intelligence has accelerated the use of health technologies. "Virtual reality" and "augmented reality" are being implemented in many areas of healthcare, from surgery to diagnosis. Through the anatomy and physiological appearance of the patient, a safe and high-quality operating system can be established in the operating room (Zbrog, 2023).

Wearable technology is rapidly advancing. Wearable technology or wearable devices can be defined as electronic devices and computers that can be easily worn on the body and integrated with clothing and jewelry (Dursun & Yilmaz 2021). There are many devices that can measure vital signs and parameters for health and diseases, and promise to improve consumers' quality of life. Healthcare should be provided through health care professionals to ensure service continuity and to increase efficiency in patient care. In the healthcare sector, maintaining a balance between the quality and cost of the most appropriate service is important and can be achieved through the use of appropriate technology. Medicine, technology applications, and healthcare services can improve the quality of life and change rapidly. Therefore, any technology that can improve the quality of life without harming human life is considered invaluable. Wearable technology is evolving by playing an effective role in individual measurements. Thanks to devices that are getting smaller and easier to carry, they are becoming tools that can measure not only clinical findings but also quality of life, fitness, and overall health. While individual measurement applications are used for data recording and monitoring, methods such as interesting visuals, warning messages, and game scores can also be used to encourage positive behavior (Aydan & Aydan 2016).

Reliable seizure detection devices can help epilepsy patients in many ways, such as minimizing premature deaths (Meritam et al., 2018). Continuous monitoring provided by many wearable technologies can make individuals more proactive about their health and have the potential to prevent future health problems. According to the data obtained from this monitoring, it helps with diagnosis instead of relying on patients' memory and clinical tests as a whole. Smartphones and other smart devices can be used to keep records to track a healthy lifestyle. These technologies support applications that can identify many chronic diseases such as Parkinson's, diabetes and heart disease. Physical activities can be recorded and reliable and accurate data can be transmitted through smartphones and other wearable devices. Research shows that data obtained from smart devices is reliable. Large amounts of data can be stored in databases to establish and analyze the link between lifestyle and disease (Aydan & Aydan 2016; Demirci 2019).

The use of artificial intelligence has become increasingly important in reducing and solving the problems that arise in the delivery and management of healthcare services. Telemedicine technologies are widely used in many areas, such as elderly care, pregnancy monitoring, home care services, and remote patient monitoring. Machine learning and artificial intelligence-based big data platforms have been developed for rapid diagnosis and treatment of diseases. The development of treatment and diagnostic protocols, drug development, personalized medicine, patient monitoring, and care can be achieved through artificial intelligence. Studies are underway on the interpretation of lung X-rays. The new technology Internet of Medical Things (IoMT) facilitates the connection and communication of all devices with each other. In the healthcare field, this technology has been successful in many areas, such as shortening emergency room waiting times for patients and monitoring medical device malfunctions (Arel, 2023).

When artificial intelligence is used for management purposes, benefits can be achieved in areas such as general health management, certification management, cost and quality management, rational use of healthcare institution capacity, addressing problems in healthcare services and management, and remote provision of complementary and preventive healthcare services. In general health service management, applications such as central physician appointment systems and eNabız data can be used to predict hospital admissions, reduce wait times in emergency departments, and standardize ambulance response times based on data collected (Akalin & Veranyurt 2020). Knowing the increasing density in healthcare institutions with the growing population makes it easier to provide correct and effective service. Every passing second, health-related data can be generated electronically on devices that people wear or use applications from anywhere in the world. Looking at the application areas of artificial intelligence for clinical purposes, it can be used in many areas such as educating the community about diseases, performing and evaluating screening tests on a large number of target groups. In summary, the use of artificial intelligence can be exemplified in many areas such as emergency intervention and early diagnosis, evaluation of radiological images, querying and monitoring test results, treatment, AI (artificial intelligence) - supported surgeries, evaluation of pathological results, medication therapy follow-up, drug development, personalized treatment, post-treatment clinical support, and home care support for patients (Akalin & Veranyurt, 2021; Cirban Ekrem & Dasikan).

"IoMT technology provides unlimited benefits that can be used in every activity in human life, independent of time and location. IoMT enables the collection and processing of data from connected devices, such as sensors, machines, and smart devices, resulting in the automatic execution of certain business plans based on the processed data. The first examples of the Internet of Things used in the healthcare sector are applications such as smart sensors, remote monitoring, and medical device integration (Sezer et al., 2018). The main idea of IoMT applications in healthcare services is the perception, processing, and remote communication of patient data without any restrictions through smart devices. Smart technologies enable individuals to achieve better health self-management and personalize the content of medical services. Thanks to wireless technologies, physiological data can be collected from sensors attached or implanted on patients at home care or away from hospitals without causing pain or disrupting their daily lives (Bicakci, 2019).

The distributed ledger technology, where blocks are linked in a chain and each block contains the hash value of the previous block, is a system in which transaction data can be encrypted with hash method and shared among members of the network. Blockchain technology ensures security through encryption, as it requires continuous verification of transactions by members and the distributed nature of transaction information prevents fraud. Therefore, the benefits of blockchain technology include transparency, trust, traceability, security, control, auditability, anonymity, scalability, and cost reduction (Ozyurek, 2021).

Technology has provided many conveniences in healthcare education. Through education, patients are equipped with the ability to manage their diseases and care correctly. Patient-specific applications designed specifically for hospitals and healthcare institutions are being used. AI algorithms, technological tools such as voice assistants and chatbots, can free up the time of professionals and increase the efficiency of healthcare services through patient education. Video-based learning, diagrams, videos, and animations can be used through tablets and mobile applications to increase individuals' understanding of their diseases, and learning can be done in the most appropriate way and at the pace that suits them best (Arkenea, 2023). Health technologies such as telemedicine, new drug development methods, data-driven healthcare services, nanomedicine, 5G-enabled devices, tricorders, smart heart pacemakers, blockchain, etc. are advanced and continue to develop (Zbrog, 2023).

Technology Use in Health Research / Innovation Project Examples

The paragraph means "health technologies refer to a field that includes all devices, drugs, vaccines, procedures, and systems designed to reduce costs and improve the quality of care in the delivery of healthcare services" (Mace, 2023). Health research also supports the development of health technology for this purpose. Research in the health field is very rich in terms of innovation (Avci, 2017).

The concept of innovation expresses both a process (renewal/rejuvenation process) and a result (innovation, new product). When we combine the definitions of innovation, it encompasses all initiatives that contribute to technology with new ideas and arrangements that result in profit. Innovation starts with new ideas and ends with commercial implementation, finally bringing innovations to the service sector. Innovation requires cost-effectiveness, higher profit, and competition both in the process and in the result (Kılıç, 2021). Innovation in healthcare has the power to respond to the needs of the system. Healthcare service innovation aims to diversify services in the treatment stages with new ideas that have outputs such as quality, safety, information protection, and cost regulation. The field that innovation covers in healthcare is very wide. The innovation process in healthcare can be carried out with comprehensive steps that include information, persuasion, decision, implementation, and approval (Avci, 2017).

Technology and innovation research provide ease in diagnosis. For example, Muhammed et al. (2020) have developed a wearable pressure sensor to measure the palm grasp reflex of newborns. The device is compatible with traditional diagnostic protocols and contributes to the working principles of pediatricians. The device has a sensitivity of 0.13 kPa-1 in a pressure range of up to 530 kPa. The grip strength of newborns has been successfully studied and examined, and the study has determined that grip behavior is associated with gender. In addition, it has been found that the palm grasp behavior changes gradually with an increase in grip strength during the first three days of life. The results showed that there is a relationship between weight loss and palm grip strength. It was concluded that the amount of weight loss during the first three days was directly proportional to palm grip strength, while weight gain was inversely proportional. As a result, it can guide the diagnosis and treatment of nervous system anomalies. In another study, an EEG device was used to measure the degree of pain, and it was found that a simple EEG device could be used to measure the degree of pain instead of traditional pain scales. In the analysis of the basic components of the device, painless data are clustered as green dots, period data as yellow dots, and migraine data as red dots. It seems possible to diagnose pain and migraine in a short time (Kagita & Mitsukura 2018). Another study, "A Wrist-worn Respiration Monitoring Device using Bio-Impedance," is designed to monitor respiration for early diagnosis of individuals with sleep apnea. Non-invasive bio-impedance (Bio-Z) is a design made of detection and ultra-thin gold e-tattoos. It is especially important for sleep apnea diagnosis due to its easy-to-wear wristband design and ability to monitor continuous respiration and blood flow. Sleep apnea is a problem that can result in morbidity and mortality, and this technology can provide a positive development in patient diagnosis and outcomes. The device continuously records accelerations on the diaphragm using an accelerometer sensor placed on the diaphragm. It effectively measures blood pressure and heart rate. When apnea is detected by the accelerometer-based system, a signal is sent. Since this system processes respiratory changes, it can be developed for respiratory pattern analysis to detect possible hyperpnea and hypopnea with apnea (Sel et al., 2020). In another study, remote monitoring of heart failure as a diagnostic method can be achieved through device-based multiple sensors. By measuring heart rate and respiratory rate through sensors, real heart failure conditions can be predicted. Thanks to remote monitoring, electronic devices have become a standard process in the management of cardiac arrhythmias in patients. The study involved 40 patients, all of whom had implanted devices with HeartLogic feature. HeartLogic-enabled devices start monitoring automatically after implantation and report to the heart pacemaker clinic when HeartLogic scores exceed a threshold of 14 (Chang ve ark., 2020). In the study titled "Bed-Based Health Monitoring Using Pressure Sensitive Technology: A Review", it has been stated that tracking parameters such as the patient's heart rate through special sensors placed on the bed can contribute to diagnosis and treatment. It has been emphasized that there is a need for increasing remote monitoring technologies like this to reduce the pressure on the healthcare system in Canada after COVID-19 (Cohen-McFarlane ve ark., 2021). The traditional ECG Holter is a bulky device that includes multiple electrodes attached to the chest. Therefore, ECG monitoring usually requires the patient to stay in the hospital for a long time. It has been advantageous to transform the devices created in current studies into ergonomic, portable, and easy-to-use equipment. This will make the provision of healthcare much easier. The study presents research on Android mobile applications using a small EKG Holter device developed for real-time arrhythmia detection. EKG signals are obtained directly through the three-electrode sensor of the EKG Holter device and then transmitted to an android smartphone via a Bluetooth module. The android mobile application is capable of analyzing and classifying the patient's EKG data to detect abnormal signs (Mahdy et al., 2018).

There are many studies that involve technology development and innovation to facilitate patient treatment and care in clinics. One of these is the development of self-injecting certolizumab pegol (CZP) for treatment. This has given patients the opportunity to experience a new electromechanical injection device, and it has been observed that patient satisfaction in this area has increased (Pouls et al., 2019). Transferring patients between bed and stretcher is a common need in patient care. Facilitating this process plays an effective role in ensuring the safety of healthcare workers and the patient. Patients in the care process face the risk of injury and falls during transport and lifting processes. Similarly, healthcare workers are also at risk of spinal and neck problems due to the risk of mechanical breakdown in their body mechanics (Hill & Schwarz, 2004). The aim of the developed device is to eliminate the extra power expended during the patient transfer process. Looking at the features of the device, it has been shown that it improves the posture of caregivers through the use of a scoop stretcher and mechanical transfer, and prevents patient injuries. The device has been designed to be ergonomic for clinical use; its embedded feet take up less space, make it easy to move around, and allow for easy installation in other clinics (Salmani Nodooshan et al., 2017). That sentence means "Monitoring physiological parameters with monitors in intensive care units and operating rooms is very important in the treatment and care process" (Kipnis et al., 2012). The need for separate invasive procedures for any type of monitoring can lead to the development of complications. Arterial pressure monitoring with an intra-arterial catheter is a standard method for patients with poor general condition and high risk. However, it can cause complications such as bleeding, infection, nerve damage, pseudoaneurysm formation, and arterial occlusion-related blood flow disorders. In this study, a compact, wireless, single-sensor technology using photoplethysmography with an improved calculation algorithm was developed to continuously monitor four physiological parameters (blood pressure, pulse rate) and provide continuous monitoring support for this issue (Tomita et al., 2018).

Continuous monitoring of patients has an important role in diagnosis and treatment. Recording and accumulating correct and regular data is crucial for planning proper treatment. While the healthcare industry is in a constant state of change, wearable technologies have increased recording capabilities in healthcare services. The developed technological device contains a glucose sensor that is implanted under the skin, allowing for continuous glucose monitoring (Thulasi ve ark., 2017). After discharge, patients are left alone to manage their treatment and care, and errors can be made during this stage. In particular, errors in self-medication by patients can lead to negative consequences of weak treatment adherence. These include an increase in readmissions to the hospital and higher treatment costs. Therefore, home monitoring of patients is important. Errors in the use of devices such as inhalers or insulin pens are common. A contactless and inconspicuous artificial intelligence study has been conducted that can detect and monitor self-medication errors by analyzing wireless signals without the need for physical contact. The sensor installed in the patient's home enables signal transmission in the Wi-Fi frequency range using frequency-modulated continuous wave (FMCW) technique. The system can analyze the data transmitted from the sensor using artificial intelligence. The embedded system in the sensor can monitor certain movements associated with self-medication and analyze radio reflections from the surroundings to determine when a patient has applied their medication using an inhaler or insulin pen. Additionally, by examining the patient's wireless reflections, an alert is generated if the patient cannot follow the appropriate technique (e.g., forgetting to fill the insulin pen or shake the inhaler). This AI-based solution works in a contactless and passive manner, reducing the burden on patients or healthcare professionals (Zhao et al., 2021).

Technology and innovation studies are also needed in elderly care. Pressure ulcers are a significant problem in the elderly. The presence of pressure ulcers reduces the quality of life of the patient. Positioning is recommended as an important preventive measure for pressure ulcers both in clinical care and home care. An automatic lateral turning device is designed as a turning platform the size of a mattress. Using the inflatable air cells inside the platform, it gently and consistently tilts patients from left to right, automatically turning them at user-defined intervals during both day and night. The system is designed to be compatible with most care bed frames and can be placed under any existing mattress (excluding pocket springs). The device's control unit can adjust time intervals and other settings to control and adapt the lateral turning positions according to the patient's needs. At the end of this study, the device's psychometric results were also examined and found to be positive (Lahmann, 2021). The need for an autonomous device that can assist caregivers in monitoring Alzheimer's patients is emphasized. Alzheimer's patients tend to have orientation disorders, confusion, and a tendency to wander off. The device is emphasized to reduce the need for assistance from caregivers for patients (Hegde et al.,2019).

These studies can help reduce healthcare costs, use reliable methods in diagnosis, diagnosis, and treatment, and save time. Emerging health technologies provide a basis for new ideas. It has been demonstrated through studies that new ideas, discoveries, and technological developments must exist in all fields, be in the discovery phase, and be applicable to the industry. Multidisciplinary studies by experts from medicine, engineering, software, and other fields are important for strengthening in this area (Kayakoku, 2022).

Intellectual Property Rights, Utility Model and Innovative Product, Patent Process

It can be observed that technology and innovation studies have diversified into idea generation, useful model, and innovative product development.

Intellectual Property Rights (IPR); The legal rights that protect products with the ability to develop society, which are the result of individuals' mental activities, including agriculture, trade, industry, service sectors, scientific fields, literature and other arts; are trademarks, patents, designs, utility models, and geographical indications. These rights are defined as "signs that ensure the distinction of the producer or seller of goods produced and sold in the trade area on behalf of the first implementers of inventions, innovations, new designs, and original works, and thus enable these individuals to have the right to produce and sell the product for a certain period of time." These signs allow the producers of inventions and innovations to distinguish themselves on the products they produce and sell in the trade area, and by registering them, they provide the right to produce and sell the product for a certain period of time (Geven, 2016). In general, it is divided into two; moral rights and economic rights. It means the protection of a person's dignity in all aspects of work. Economic rights, on the other hand, are the rights that provide the provision and follow-up of technology along with skills and resources. Additionally, it provides a competitive advantage and income to the individual (Parlakyıldız, 2011; Guvel, 2015).

IPR applies to inventions or innovative product patent applications that have not yet been published in any written or oral form worldwide. The patent or utility model holder is granted exclusive rights for a limited time and place, preventing third parties from producing, selling, using or importing the invention without permission. These rights prevent others from using and selling the invention without the creator's permission (Emiroglu, 2018).

Invention; An invention forms the basis of the patent concept. An invention is the explanation of a problem with a new method or new technology. It is a collection of innovations that provide a technical solution to a problem. These innovations can be in the form of a new machine, product, chemical compound, method, or they can also be improvements made to something that is already known. Before applying for a patent, preliminary research should be conducted. It should be determined whether the work actually contains a subject that is eligible for a patent. All current sources should be reviewed in research. In addition, scientific sources, publications such as articles and conferences, should be scanned, and most importantly, patent databases should be consulted (Kayakoku, 2022). There are free internet sites that you can use to find out if your invention is new;

- European Patent Office database (http://tr.espacenet.com , http://worldwide.espacenet.com)
- World Intellectual Property Organization database (https://www.wipo.int/portal/en/index.html)
- United States Patent and Trademark Office database

  (https://www.uspto.gov/)

- Google Patents database (https://patents.google.com/)

- Turkish Patent and Trademark Office database (https://portal.turkpatent.gov.tr/)

Patent; In English, the paragraph would be: "Patents are documents that provide inventors with the right to "produce, use, sell or import" the technologies they have developed and created for a certain period of time. With this document, all kinds of protection rights are provided for original designs and ideas. Patents are the most important output of Research and Development (R&D) activity (Altuntas & Yilmaz, 2017). Patents are granted to inventions in various fields of technology under certain conditions. Conditions such as the novelty, industrial applicability, and originality of a new invention play an important role in granting patent rights. The patent holder has the right to prevent others from commercially using, producing, selling, importing, or exporting the patented invention without permission (Turk Patent, 2023). Patent rights apply to inventions, provided that the patentability criteria are met. This situation, which is applied similarly all over the world, is expressed in Article 82 of the Industrial Property Law (Sınai Mülkiyet Kanunu) No. 6769 in Turkey, which describes patent rights as follows: "Patents are granted for inventions in all fields of technology, provided that they are new, involve an inventive step, and are capable of industrial application" (Sınai Mülkiyet Kanunu, 2017). Although they may be considered inventions, the following subjects have been excluded from patentability in the Industrial Property Law:

- Inventions contrary to public order or morality,
- Biological processes primarily related to the production of plants or animals, except microbiological processes and products obtained through these processes,
- Diagnostic methods for the application to the human or animal body and surgical methods, as well as all therapeutic methods,
- The mere discovery of the formation and development of any element of the human body at any stage of its formation or development, including a sequence or partial sequence of a gene,
- Human cloning processes, changing the genetic identity of the germ line of human beings, using human embryos for industrial or commercial purposes,
- Genetic identity-changing procedures that inflict suffering on animals, as well as animals obtained from such procedures, without providing significant medical benefits to humans or animals. (Ozsahin, 2017)

Patent Process

The importance of the invention in a patent application notwithstanding, the application process is based on the characteristics that can be described in the patent. Patent applications should contain the most detailed, clear, and specific information that makes up the technical framework of the planned subject/developed product. After it is determined that the application is of sufficient importance, all technical and written details must be written with visuals and descriptions. The application is first submitted to the Turkish Patent and Trademark Office and then examined for its form, and adjustments are made. When the legal process is complete, the application document is officially published. At the end of the process, the registration of the invention that has been definitively granted a patent is announced (Kayakoku, 2022). The "Turkish Patent and Trademark Office" has prepared the "Patent / Utility Model Application Guide" to guide applications in Turkey. "The following guide explains in detail with examples how the application should be prepared and what elements it consists of. Applications must be made only online via the Electronic Application System, using e-Government password, electronic signature, mobile signature or internet banking, through the address "https://epats.turkpatent.gov.tr/run/TP/EDEVLET/giris" after logging in." (Turk Patent, 2023). The patent certificate provides exclusive rights to an individual. There is an opportunity to prevent others from using the invention for a certain period of time. The patent only grants ownership for the country in which it was obtained; separate applications are required for other countries (Emiroglu, 2018). Granting a patent;

- The process of granting a patent consists of several stages, including:
- Examination of the application for compliance with formal requirements
- Request for search, preparation and publication of a search report
- Publication of the application and its effects
- Request for examination, preparation of examination report, and granting of the patent. (Sinai Mulkiyet Kanunu, 2017).
- The patent application process is summarized in Figure 1 (Turk Patent, 2023).

The utility model process is similar to the patent process. Like a patent, an industrial applicability and novelty publication are required for a utility model document. Novelty means that it must not have been disclosed or used in any form, neither in writing nor otherwise, and must be accessible to everyone in the world. It must be applicable and practical for the industry. (Emiroglu, 2018). Both patents and utility models can differ in terms of "patentability criteria, types of inventions that can be protected, registration process, and protection process". In inventions protected by patents, all three criteria of novelty, inventive step, and industrial applicability must be met, while for inventions protected by utility models, it is sufficient to meet the criteria of novelty and industrial applicability (Kayakoku, 2022).

Figure 1
Patent Process

There are many differences between the registration processes for patent applications and utility model applications. One of the most important differences is that both the research and examination stages are required for patent applications, while only the research process is conducted for utility model applications. There is no examination stage for utility models. In terms of protection, according to Article 101 of the Industrial Property Law, "the protection period is 20 years from the application date for patents, and 10 years for utility models, and these periods cannot be extended" (Kayakoku, 2022). The third paragraph roughly translates to: According to Article 3 of Article 142 of the Industrial Property Law, useful models are not preferred for biological and chemical substances or products obtained by methods, products related to pharmacy, and biotechnological inventions. Patent protection is more appropriate for these products, and they cannot be protected by a useful model document. The patent right ends when the protection period expires, the patent owner abandons the patent right, or both the annual fees and additional fees are not paid within the specified periods due to various reasons (Turk Patent, 2023).

In summary, this section covers the broad foundations of innovation, technology, and patent processes. In health research, the aim is to improve the quality of healthcare service delivery, protect service providers, increase the number of people benefiting from care and treatment services, and also reduce the cost. Innovation efforts and technology development will contribute to achieving these goals.

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Similarity Index :
The similarity index obtained from the plagiarism software for this book chapter is 9%.

To Cite This Chapter:
Birer, Z. & Faydalı, S. (2023). The Use of Technology in Health Research. In S.N. Guner, Y. Uzun & I. Cetin (Eds.), *Current Studies in Healthcare and Technology* (pp.180–194). ISRES Publishing.

CHAPTER 15

Health and Technology

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Health And Technology

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Introduction

Technology is all of the tools developed by people to control and change their environment and the information about these tools. Health technology has been defined by the World Health Organization as the systematic application of knowledge, skills and tools developed to improve living standards by solving a health problem.

Health care is a service that is provided continuously and the need for this service changes over time. Thanks to technological developments, advances in health care have brought about an improvement in the mortality and morbidity of diseases. With the increase in discoveries in basic sciences, breakthroughs in artificial intelligence, biotechnology, nanotechnology, digital technology, engineering, robotic methods have improved medical science. Thanks to these developments, early diagnosis, prevention of diseases, better explanation of disease models, ensuring continuity in patient care and improving health service delivery are also possible (Dzau & Balatbat, 2018).

In addition to the positive effects of biomedical technological developments, it also includes some possible risks such as ethical problems, lack of confidentiality of data, and cyber security vulnerabilities. While evaluating the contributions of technological developments in health, inferences should be made by considering the risks that come with these developments. The possibility of increasing health care costs due to new technologies is a concern. The cost increase in health services is known as a global problem today. In a study stating that health costs will be 18.28 trillion dollars in 2040, it was reported that these costs were 7.83 trillion dollars in 2013 data (Dieleman et al., 2016). Meeting the costs and ensuring that individuals have equal access to services are the challenges that come with technological developments. With the advancement of technology, it is important that the developments in health care can be delivered to all individuals rather than benefiting certain individuals in the society. The fact that the technologies needed in health care become more complex and expensive complicates the access to medical aid and paves the way for socio-economic problems. Technological R&D studies that cause high costs and the use of developed technology may have positive effects on health costs in the long run. Long-term cost analyzes of health technologies are needed.

Development of Health Technology

Fundamental changes in medical science that developed efficient health systems occurred in the late 20th and early 21st centuries. Major breakthroughs in basic sciences in the 20th century opened the door to progress in medical science (Paltsev, 2008; Bircher, 2007). In this way, tools have been developed for the prevention and treatment of diseases that were once considered quite deadly, such as diabetes, hypertension, bleeding diathesis. One of the greatest developments of the 20th century is the more effective use of hygiene and sterilization, which ensures the prevention of infectious diseases (Troy et al., 2002).

The discovery of X-rays and its use in health have provided a very important convenience in the diagnosis of diseases. A better understanding of microorganisms and learning the vital properties of cells have become possible with the development of microscopic tools. The fact that intensive care healthcare services have become more effective has enabled long-lasting major surgeries to be performed. Minimally invasive procedures such as angioplasty in the treatment of atherosclerotic heart diseases, unstable angina and heart attacks have created radical changes in cardiology in the last 15 years. Thanks to these and similar developments in health technology, a significant decrease in infant mortality rates was observed in the last century. In addition, the average life expectancy has increased by 30 years compared to the beginning of the 20th century.

Table 1

Significant Developments in Health Until the End of the 20th Century with the Help of Technology

Year	Development
1900 - 1915	Diphtheria serotherapy Identification of Plasmodium as a malaria agent Understanding the importance of the immune system
1915 - 1940	X-ray discovery Understanding the importance of preventive medicine Improvement of hygiene and sterilization Development of penicillin Discovery of blood groups and Rh factor
1940 - 1970	Medical use of ultrasonography Application of endoscopic interventions First kidney transplant Lithium use in psychiatric disorders Production of antipolymyelitis vaccine Lung and liver transplantation Aorto-coronary shunt surgery heart transplantation

Year	Development
1900 - 1915	Diphtheria serotherapy Identification of Plasmodium as a malaria agent Understanding the importance of the immune system
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1970 - 1999	Medical use of computed tomography Analyzing the human genome

Technological Tools and Applications in Health

Biomedical Technologies

Cell technologies such as tissue engineering products, genetic therapy, nanotechnology and biotechnological drugs are promising biomedical technologies.

a. Cell Technologies

Tissue engineering technologies, which can create many tissues from cells, such as cartilage, bone or nervous system elements, may lead to great transformations in health in the future. In this way, the functions of the organs affected by the diseases can be restored (Zeiher, 2007).

b. Gene Technologies

Especially gene technologies, which support important discoveries in contemporary pharmacotherapy, lead to more effective measures against infectious diseases. The number of vaccines produced against hundreds of known pathogens in the last century was found to be quite insufficient in studies (Logunov, 2008). Molecular and genetic technologies enable genetically modified vaccines. Serious public health problems can be prevented thanks to these vaccines, whose availability is expected to increase in the next decade.

c. Nanotechnology

Working with particles in a millionth of a millimeter, nanotechnology is another promising area in health technologies. With this technology, whose therapeutic effects are investigated at the molecular level in cells, it is possible to give isolated interactions between proteins, target interactions with DNA, and medical treatments to small structures such as cell organelles. Biological nanostructures used in branches such as dermatology, neurosurgery and orthopedics that use medical implants are another important benefit of nanotechnology.

d. Biotechnical Drugs

The fastest growing sector of biomedical technologies is the biotechnical pharmaceutical sector. With these studies, biological activity is realized, not pharmacological effects. Microorganisms or cells of animal origin are used more frequently in biotechnical drugs produced using active substances of biological origin. The difference of these drugs from genetically modified microorganisms is the use of the natural biological activities of the substrates. This use is achieved by isolating the substrate DNA intended for biosynthesis.

Information Communication Technologies

Information and communication technologies have an important role in improving health care, increasing the quality of service and ensuring the continuity of health care. With the development of information and communication technologies, progress has been made in health services, which include planning, administration, prevention, diagnosis, treatment and follow-up applications. In addition, with information and communication technologies, it is possible to continuously renew themselves and to work effectively on updated medical scientific knowledge. In addition to the convenience provided by these technologies, communication between colleagues is also carried out effectively. On the other hand, there are some who report that electronic health records cause burnout of doctors and disrupt the doctor-patient relationship.

a. Telemedicine

It is the use of telecommunications to deliver health care to distant places. In this way, doctors can make consultations with relevant specialists and make more effective decisions in a short time when faced with complex problems (Karsenti, 2008).

b. E-Health

Health service management, policies and the provision of health services were formed by getting support from the internet. Thanks to e-health, data analysis, warning mechanisms and precautionary applications have been developed. In addition, with this system, patients are provided with information about their own condition.

c. Web-based seminar (Webinar)

It is a live broadcast where conferences and meetings are held simultaneously on the internet. In this way, participants from different places can take part in the same conference.

d. Webcast

Media contents in the form of live broadcast or recording can be presented to more than one person on the internet via webcasts. The contents on the server can be accessed by users.

e. Online Learning Platforms

Adaptable online learning platforms that create opportunities in the field of social media and education can be given as examples within information and communication technologies in health.

Health Technology and Transformation

Technological developments cause some jobs to disappear, some jobs to be transformed, and some new business areas to be created, as it has done so far. This situation shows the significant effects of technological developments on the workforce. For example, with the production of robots with artificial intelligence, certain professions may decrease gradually. It is predicted that developments in artificial intelligence will change the way, place and duration of service delivery in health. By using artificial intelligence, radiological examinations, laboratory results and electrophysiological tests will be interpreted. Trained personnel are needed in order to operate the technological systems that are in use and to maintain the services. This has led to the emergence of new business lines. Transformations and new formations in the existing workforce increase the importance of education and training policies in these areas.

It is necessary to increase the knowledge, skills and education quality in order to effectively use the human-machine cooperation that occurs with technological developments. With the technological developments, the way of providing health services at the homes of the patients has been cleared by moving away from the hospitals. In addition, the increase in the effectiveness of prevention will also reduce the patient burden in clinics. Health technologies have increased the knowledge of patients about their own condition and have enabled them to make more free choices about the treatment they will receive.

Health Technology and Ethics

Ethical problems arise because of people's decisions and behaviors. For this reason, holding technology itself responsible for ethical problems may prevent the production of rational solutions. It is very important to understand the importance that should be given to ethical issues while educating physicians.

Thanks to medical technologies, whose development has accelerated in recent years, easier diagnosis and more effective treatment of health-related problems has emerged. The average lifespan of people has increased and individuals have become healthier than in previous decades. Thus, technological developments have been rapidly adopted by societies. Efforts to adapt to technological developments at an unconscious speed carry the risk of inappropriate use, and this situation brings ethical problems. These ethical issues are grouped under three main headings as problems related to patient safety, difficulties in equitable use of tools, and effects on social norms. For example, failure to meet technical education and training requirements can result in fatal misuse. Due to the pressures on the use of new technologies by doctors as soon as possible, there is a lack of technical knowledge and skills. There is a learning curve for the smooth implementation of dexterous developments. For example, in the first applications of laparoscopic methods, more complications were encountered than open surgery.

Giving privileges to wealthy and powerful groups in the society in health technologies prevents fair presentation. It can have transformative effects on personal or social norms, as it can be used for purposes such as looking beautiful, gaining a strong memory, becoming stronger without any disease. The social pressure on those who ensure that health technology is delivered to the community stakeholders is another important feature of this issue. These pressures on health professionals may prevent the effective use of resources allocated for health costs by causing excessive and unnecessary use of technology. Unnecessary tomography scans, off-label use of 3rd generation cephalosporins, off-label cesarean section are some examples of these.

Developments in science and technology have caused some social and ethical concerns to come to the fore in all areas of concern to society. The services provided must be delivered to individuals in a fair and equitable manner. In addition, developing technologies can affect the cultural structures and belief orientations of some societies. Technological developments can affect family structure, attitudes towards disability, and religious behavior patterns. For example, if people with disabilities do not accept the genetic treatments developed, it is necessary to ensure that they continue their lives without being excluded. There may also be an increase in social inequalities as genetic improvement methods become more successful. If the advantages brought by technological opportunities are monopolized by certain groups, it may become open to abuse. For this reason, it is of great importance to make equitable legal arrangements in accordance with the dynamics of each country, taking into account the views of all stakeholders. The increase in information records also raises concerns about the security of this information. Healthcare is one of the sectors most frequently targeted by cyberattacks. Equipping technological health systems with protection systems against cyber attacks is another important requirement.

Conclusion

Health technology aims to detect diseases early, develop minimally invasive procedures, reduce the need for hospitals, reduce healthcare costs and improve quality of life. Whatever the reason may be, it is impossible to prevent scientific and technological developments. The inevitable developments in 21st century health technology have brought about many changes. These changes have brought great benefits to public health by making life comfortable in many issues. In addition, it has brought many new problems such as artificial intelligence overshadowing human intelligence, smart devices destroying the respect for hand skills, and the medical profession has become more passive. In addition, the questions of what will be the limits of the use of technological developments in the human body, what kind of hospitals should be established in the future, and how safe new technologies are, come to mind with increasing frequency. In this respect, it is necessary to make an effort to foresee the situations that will be encountered in the future. Continuing to gain momentum in science and technology in the next decade will bring transformative changes in health. Thus, there will be tools and approaches that make it possible for health services to become better for society and individuals. It is necessary to work to be aware of social, economic and ethical risks and to take necessary precautions against them. Along with the technological developments in medicine, physicians who have to constantly improve their medical knowledge also need to have information about technological tools. Due to the need for technological tools in health care, doctors spend more time in front of technological tools such as computers. It is necessary to know that it will be a disadvantage for the patients to move away from the doctors.

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Similarity Index :
The similarity index obtained from the plagiarism software for this book chapter is 3%.

To Cite This Chapter:
Kenan, M. & Yuksek, ME. (2023). Health And Technology. In S.N. Guner, Y. Uzun & I. Cetin (Eds.), *Current Studies in Healthcare and Technology* (pp.195–202). ISRES Publishing

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CHAPTER 16

Neurosurgical Techniques and Training in Three-Dimensional Models

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Neurosurgical Techniques and Training in Three-Dimensional Models

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Introduction

The use of three-dimensional (3D) printing models in neurosurgery has become increasingly widespread in recent years for surgical training, pre-surgical planning and specialist training. In spinal surgery, which is anatomically variable and a challenging area in practice, it is important that surgeons adapt to the anatomy of the individual patient.

Both the training and learning of complex surgical procedures applied in the specialty of Brain Surgery training is quite difficult. Many studies have supported that this challenging training process is completed more effectively with the use of three-dimensional models, and these models are gaining importance in brain surgery training tools (Bohl et al., 2019).

One of the major disciplines of medicine is anatomy. Classically, surgical neuroanatomy is often learned from 2-dimensional images in books or from cadavers that can rarely be obtained. Digital presentations, video recordings and two-dimensional visual methods are still used today for the anatomy training of medical students and surgeon assistants. (Kurt et al., 2013). Three-dimensional training of branches with spatial characteristics such as anatomy will lead to much more successful results. Cadavers continue to be the gold standard for applied neuroanatomy training today, they are at a disadvantage compared to 3D models in terms of storage difficulty and cost. In addition, it is not possible to provide cadavers and storage facilities in every medical training center. Among its disadvantages is long-term exposure to formalin solutions used to protect the cadavers, which are harmful to health. (Hauptmann et al., 2009).

3D prints of anatomical structures produce physical models for pre-operative planning and applied training. Also, surgical intervention can be simulated with these models. Realistic simulations that allow the surgeon to try the operation at the desired frequency reduce the incidence of patients exposed to complications that may arise during surgery (Anderson et al., 2016) (Mashiko et al., 2015). 3D printing technology, which can also be used for the manufacture of surgical devices, can produce instruments and implants suitable for the patient's own anatomy (Chang et al., 2014). Thanks to technologies such as intraoperative navigation and 3D modeling, better clinical outcomes and reduced rates of complications in spinal surgery have been.

3D implants are specific to the patient and one of their advantages over traditional implants is the possibility of printing the porous structure of the trabecular bone. Thus, better anatomical matches and fusion are possible due to the inclusion of the biological components in the bone structure as well as the patient's suitability with its own anatomy in terms of shape and size. (Liebsch et al., 2020). If effective and routine clinical use of 3D printing methods is ensured, this will revolutionize the treatment of many spinal diseases.

History and Development Stages

The three-dimensional printer technology was first introduced in 1981 by Dr Hideo Kodama to produce a device using ultraviolet rays (Attarilar et al., 2021). The technology then developed by Charles Hull led to the production of the first three-dimensional printer in 1983. There has been a continuous development since then until now. The modeling information of printers capable of producing models in almost every structure and geometry is obtained from routine pre-operative imaging (magnetic resonance imaging, computed tomography, etc.) (Azlin et al., 2022).

The first use of 3D models in spinal surgery was in 1999 as a method to assist with imaging in patients with severe spinal deformity (D'Urso et al., 1999). In these studies, D'urso and ark. used 3D anatomical models in the treatment of spinal deformities, occipital and maxillary lesions caused by osteogenesis imperfecta (Yang et al., 2015).

The increasing prevalence of affordable 3D printing software and hardware has promoted the adoption and exploration of clinical use as a technology. Clinical 3D printing units have been established in the United States as a subsidiary of clinical departments. The establishment of these units aims at the mass production of 3D models to be used in surgical planning, instruction or assistant training. In these units, it allows clinicians from different fields of expertise to take advantage of manufacturing services to obtain 3D models.

3D printing technology has contributed to many medical fields including the pharmaceutical industry, plastic surgery, brain surgery, and orthopedics (Fan et al., 2020) (D'Urso et al, 1999). 3D technology is a field that has proven importance in the production of anatomical prostheses, surgical practice, training and planning, production of tissue and organ models. (Mukherjee et al., 2017). 3D printing techniques have evolved over time and reached standards that can be used in medical applications. Orthopedics, plastic surgery, spinal surgery have been the first branches to use these techniques in the clinic.

Technologies

3-Dimensional printing techniques are techniques in which various manipulations are performed to create 3-dimensional objects. Additional or extractive methods have been used in printing. Extractive method is known as Computer Numerical Controlled (CNC). The biggest disadvantage of this method used to create 3-dimensional models is that it requires a variety of materials such as cartridges, seals, jails, and requires intense vehicle change (Largo & Garvey, 2018). The negative feature of the extractive production method is the difficulty of transporting the materials used as cutters into the manufactured objects. Thus, it is difficult to create detailed internal structures with this method. Due to these limitations, additional methods to the production of 3D printing are preferred. The first person to describe the additive manufacturing technique was Charles Hull in the early 1980s, and with additive production the development of 3D printing accelerated. Stereolithography (SLA) used in the first 3D printers was a costly and time-consuming method. In the SLA method, the liquid is hardened by heating with the help of a photopolymer laser. The thickness of the solid layers formed with the help of heat is 0.05 - 0.15 millimeters. Then another layer is formed onto the solid layer with liquid resin (Pham & Gault, 1998). These processes are repeated in order to reduce defects in the surface coating and increase the print resolution. (Ian Gibson, 2015). The resolution can be reached up to 100 nanometers. After the printing process is completed, the resulting product is hardened in an ultraviolet (UV) section. These products are hydroscopic due to their potential to show flexibility in humid environments(Chae et al., 2015). The hardening process with UV rays makes the products more fragile. Despite its restrictive properties, this method is used for medical purposes due to its resistance to autoclavic sterilization.

In 1988, Carl Deckard patented the Selective Laser Sintering (SLS) method (Ventola, 2014). Unlike SLA, SLS uses laser to heat solid dust materials (Hoy, 2013). Laser heating is applied to the product covered with the dust layer to ensure the coating of the layer, and then this process is repeated by forming the powder layer again (Pham & Gault, 1998). The thickness of the powder layers welded by heating can range from 0.06 mm to 0.15 mm. Products created with SLS, which have the advantage of using many materials such as plastic, metal and ceramic, have a fairly wide range of uses. Pre-process heating and post-cooling period increases the need for time in production with SLS (Ian Gibson, 2015). The SLS method requires an experienced specialist due to its internal structure that contains nitrogen and can reach high temperatures (Chae et al., 2015).

The Fused Filament Manufacturing (FFM) printer patent was acquired by Scott Crump and his company in 1992, and Fused Accumulation Modeling (FAM) technique is the most commonly used method today. In this technique, the thermoplastic material is sprayed out of the mouthpiece into a thin layer by heating. After each layer is created, the printing bed is moved to the next layer, subdued by the device thinner than one millimeter. According to other techniques, in this method, which is both easier to use and less expensive, the print resolution varies according to the thickness of the mouthpiece. As the resolution increases, the time increases. (Ian Gibson, 2015). The disadvantage is that only thermoplastic materials can be used. Also, the maximum resolution is less than techniques that can increase the resolution with laser diameter such as SLS or SLA (Pham & Gault, 1998). In 1994, with the addition of 3D printing technologies to the 2D inkjet printer mechanisms, material spraying 3D printers were developed. These printers have been able to place thin layers of resin with advanced technology and then perform rapid hardening process with strong UV rays. These printers can print at a resolution of 0.016 to 0.028 mm and can simultaneously print multiple materials at room temperature (Ventola, 2014) (Chae et al., 2015). Material-spraying printers are more affordable than those containing lasers. There is no support provided by the printing material under the printed product in this method. Therefore, it is necessary to create support in order to be able to print correctly, and these supports must be removed by completion of printing. Thermoplastics and photopolymers can be used as printing materials (Ian Gibson, 2015).

Binding spray printers, which began to develop in 1995, work in a similar way to printers that spray printing materials. 3D printing is done in a dust depot and requires no supporting structure (Chae et al., 2015). With this technique, products with multiple colors can be printed in one layer. This feature is useful in the production of anatomical models (Ligon et al., 2017). It is a cost-effective and fast production method.

The digital light processing (DLP) method, obtained with the development of SLA technology and produced in 2000, directs light to photoreactive polymers with the help of a series of micro mirrors (Kessler et al., 2020). Photoreactive liquid polymers used as printing materials harden after exposure to light. The resolution of the models produced by this method is proportional to the number of mirrors. Because of the digital projector, the sizes are larger than the SLA. It creates harder surfaces than SLA due to its cornered voksels. This is a quick method because all layers can be printed simultaneously (Zhang et al., 2019).

With the Continuous Liquid Interface technology (CLIP) developed in 2013, the printing method can print faster than DLP. The hardening of the liquid material by the thermal effect is similar to DLP, but the dead area is reduced because it has an oxygen-transmitting membrane and the liquid interface is preserved. Continuity is ensured during the printing process with the protection of the liquid interface. The disadvantage is that this technique is quite expensive.

Materials

The choice of materials is important to produce realistic models. The materials used in 3D printing can be studied in four main heads: polymers, metals, ceramics and composites.

Compared to metals and ceramics, because the melting temperature is low, the cost is reasonable and easy to shape, the polymers are advantageous in work that requires rapid printing. Metal materials are conductive, ceramic materials are insulating. Corrosion resistance in metals is less than in polymers. The polymers are advantageous because of their high strength.

Ceramics are harder than other materials. Composites are manufactured using three groups of materials. Thus, it is intended to bring together the advantages of each. Models produced for medical purposes must have different characteristics depending on the areas in which they are used. Composite materials used in many 3D printing applications today can be produced in different strength, flexibility, durability and cost models. Implants must be corrosion-resistant and adapt to the surrounding tissue.

a.Polymers

Acrylic resins, the first 3D printed material, are used in the manufacture of detailed anatomical models (Zenha et al., 2011). Acrylic resins, often mentioned in literature, are lightweight and durable (Winder & Bibb, 2005). Because acrylic resins are hydroscopic, bending and tilt can occur when exposed to moisture. (Winder & Bibb, 2005). Long-term exposure to UV rays also causes them to deteriorate (Tröger et al., 2008).Polyester ether ketone (PEEK) is used in the manufacture of cranium and orbital implants. This product, which is a thermoplastic material, is highly biocompatible due to its similar characteristics to bone structure. (Lethaus et al., 2014). The PEEK material is resistant to autoclavic sterilization, and techniques such as SLS, which can print at high temperature, are required to be able to model (Schmidt et al., 2007).

Transparent colored polystyrenes are affordable, lightweight and tough. Because of its hardness, the grinding, cutting and gluing processes are relatively easy to apply.

According to Peek, its resistance to heat is quite weak. (Shi et al., 2008). Because it is more rugged than other plastic materials, polystyrenes are fragile to bend. (Ligon et al., 2017). If rubber or polyamide is added to the polystyrene material, the fragility can be reduced (Ligon et al., 2017).

The characteristics of polyamide (PA) models vary depending on the carbon atoms in their chemical structure. (Griehl & Ruestem, 1970). The PA-12 is affordable in terms of acrylic resins, is resistant to autoclavic sterilization, lightweight, corrosion resistant (Leiggener et al., 2009). Substances such as carbon or aluminum can be added to PA-12 to increase its endurance. It is a nylon that is resistant to moisture and water and has a high biological fit tolerance. (Griehl & Ruestem, 1970).

The most preferred polylactic acid (PLA) and acrylonitrile budadien stiren (ABS) in FDM printers are thermoplastic materials that can be sterilized. The natural structure of these materials, which also have different colors, can be damaged by autoclavic sterilization or dry thermal sterilisation. In both materials, shape changes can be seen in long-term exposure to moisture. No toxic gases are observed during the printing of PLA. PLA has disadvantages such as being biologically biodegradable and absorbable (Zakhary & Thakker, 2017). In the PLA material, the risk of observing inflammatory reaction by the tissues in which it was implanted has been. (Goth et al., 2012). Another advantage of ABS is that it is easy to develop using composite materials to make it more resistant to various stressors such as pressure and heat. (Ligon et al., 2017).

b. Metals

The strength of titanium used in many reconstruction plates and implants can be increased by alloying with aluminum and vanadium. (Hansen, 2008). Compatible with bone tissue, titanium is suitable for siterilization and has the ability to print perpendicularly for better osseointegration (Rotaru et al., 2015). It also shows tolerance for bending and stretching to give proper shape during operation. (Zakhary & Thakker, 2017). It produces radiation during modeling while being less than metal implants such as vitalium or steel. (Zakhary & Thakker, 2017). The radiopaque nature of the metal is important for postoperative evaluation. Today, its use for fixing bone fractures is the gold standard.

The cost of stainless steel is more convenient than titanium and the durability is higher (Zakhary & Thakker, 2017). Steel materials can also be pressed by laser sintering, such as those of titanium. Nickel alloy steels emit radiation during production, causing allergic reactions. Steel materials are alloyed with titanium in order to enhance biocompatibility and make them more durable (Hansen, 2008).

c. Ceramic

Ceramic materials are less preferred in medical 3D modeling than others (Ian Gibson, 2015). Aluminium nitrate, clay, metal oxides, carbs and nitrites are used in ceramic printing. Due to the difficulties of sterilization, the number of models created using a handle is limited. In addition, these models are more fragile and less water resistant. (Mehra et al., 2011). Models made using ceramic materials need to be compressed at the end of the process. This app reduces the volume of 3D models by 12-18%.

d. Composite

Composite materials that are increasingly used in 3D printers provide high resolution and durability. According to the characteristics required in 3D models, additional alloys can be made to composite materials. Materials such as nylon and ABS, for example, can be combined with glass and carbon, or resins can be made resistant to combustion with aluminum trihydrate and halogenation. (Ian Gibson, 2015). With this technology, the addition of polykaprolactone, collagen, hydroxyapatite or calcium silicate to bone implants has been studied in order to increase biological adaptation tolerance. In models intended for medical use, the addition of drugs or growth factors for the same purpose is also investigated (Inzana et al., 2014).

In the last half-century, developments in 3D printing technologies have also increased the variety of materials used. In 3D printing applications, it is important to first know the parameters such as model size, the material characteristics required for the model, the reasonable cost, the required time to produce the required number of models. Medical materials produced by 3-dimensional printing methods must be resistant to sterilization exposure more than once and also ensure cost-effectiveness. Manufactured grafts or prostheses for soft tissues should be in line with the biological structure, quality imitating the actual tissue sensation and appearance.

Figure 1

C1 (Atlas) 3D model of the spine created using real patient images and lateral mass screw applied for educational purposes (Computerized Tomography Imaging of Top Series Models, Photos of Sub-Series Models)

Benefits of Use

In a study in which the intraoperative and postoperative characteristics of surgeries performed using 3D models compared to normal operations were studied, it was concluded that perioperative blood loss, duration of the operation, rates of complications and the need for blood transfusion decreased but some increase in healthcare costs. (Madrazo et al., 2009). Furthermore, surgeries using 3D printed models have significant reductions in patients' anxiety-related pain by informing patients that this technology will be used (Guarino et al., 2007).

By contributing of 3D printed models to surgical planning, surgeons can understand parameters in more detail, such as implants to be placed in complex anatomy and the degree of correction required in spinal scoliosis. (Garg & Mehta, 2018). The instruments placed in the 3D printed model guide have higher placement accuracy and a reduction in pedicular cortex perforation, surgical duration and frequency of use of floroscopy has been. (Garg et al., 2019). Thus, in the instruments applied at the cervical level, the damage to the vertebral artery can also be predicted to be reduced. (Lu et al., 2009). With pre-operative planning using 3D-printed models, intraoperational planning and instability conditions were transferred to the preoperative stage, the ergonomics of the surgery was improved, and the duration of the operation was reduced. (Thayaparan et al., 2019). Reduced operating time is to bring with it the reduction in surgical area infections. (Mobbs et al., 2019).

3D models allow visualization of complex pathologies, and the visualized anatomical structures are personal. (Gao et al., 2017). The ability to create patient-specific implants leads to better adaptation of the implants placed, which increases long-term positive functional results. (Walha & Fairbanks, 2021). Predictions are promising, such as the presence of implants that can be customized with 3D printing technologies, the possibility of producing porous implants for more efficient fusion, and that these implants can be processed with released medicines or substances. The possibilities arising with these predictions also shape the future of 3D printing used in spinal surgery. The production of interbody fusion cages and artificial spinal vertebral body implants by using 3D printers increases the production of micro-spinal structures. The use in clinical applications by producing specific implants to each patient's own anatomy can be used in atlantaxial, sacral tumor surgeries and in the treatment of spinal deformities.

Because it is harder to manufacture implants outside of certain geometric shapes by conventional methods, 3D printing of structures in irregular forms will be preferred in the future.

Studies have comparing training with 3D models with 2D methods. Better results were in training areas with 3D models in terms of correct response rates and test times in the tests used in these studies (Brewer et al., 2012) (Berney et al., 2015). In the study of these comparisons, students and assistants preferred to work with 3D sources in a meaningful proportion. (Brewer et al., 2012).

Restrictions on the Use of 3D Medical Printing

1. Time

The time needed for printers to produce 3D models prevents them from being used in diseases that require emergency neurosurgery. (Lan et al., 2016). The 3D printing procedure, which takes half a day even when all technical requirements are met, remains slow in emergencies (Martelli et al., 2016). Although it is known that there are high-resolution devices that can print quickly, studies are needed to show that these devices can be used in brain surgery practice (Xu et al., 2021).

2. Material

There is no established international standard on the choice of materials used in 3D models. Doctors prefer the material based on clinical experience because they cannot choose with reliable markers and experimental evidence (Yan et al., 2018).

3. Property

The cost of the parts created on 3D printers varies depending on the production facilities and materials. It is not possible to high quality standards with every 3D printer on the market. The cost of installing 3D modeling centers and the need for experienced professional staff make this technology quite expensive in most clinics. When 3D anatomical models are designed, different materials are needed to create different tissues, such as skeleton, muscle, fat tissue or crust. The lack of a single material for soft tissues and skeletal tissues is also a significant cost-increasing limitation.

Time, materials and human resources increase the cost of 3D printing in proportion (Tack et al., 2016).

4. Knowledge and Skill

Although 3D printing methods have increased in research related to clinical applications, the need for quite specialized equipment and trained personnel has prevented their widespread use in clinical practices. (Ashouri-Sanjani et al., 2021). In addition, in the absence of clinical prevalence, it may also be effective that spinal surgeons are unaware of the widespread uses of 3D printing.

The lack of technical knowledge and skills of surgeons about 3D printers has led to a slower adoption of 3D printing methods in medicine. 3D printing methods that do not reach large numbers due to health regulations also have negative effects on their applications in vertebral surgery.

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Arac, D. & Yuksek, M. E. (2023).Neurochirurgical Surgery Techniques and Training in Three-Dimensional Models.In S.N. Guner, Y. Uzun & I. Cetin (Eds.), *Current Studies in Healthcare and Technology* (pp.203–217). ISRES Publishing.

CHAPTER 17

Current Technological Approaches in Physiotherapy and Occupational Therapy

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Current Technological Approaches in Physiotherapy and Occupational Therapy

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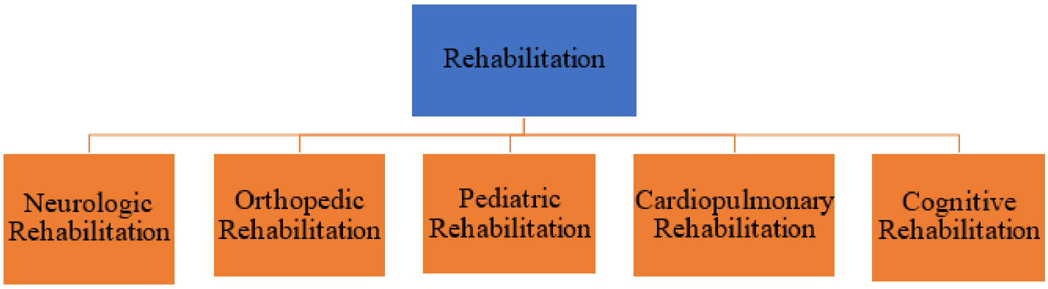
University of Health Science

Introduction

Rehabilitation aims to improve the patient's quality of life and social cohesion by maintaining independence in activities, minimizing pain and disability, and improving the ability to adapt to changing conditions. It is a problem-solving process shaped within the framework of the holistic biopsychosocial model and is presented with an individual-centered approach. It is carried out under the guidance of a specialized and multidisciplinary health team such as physicians, physiotherapists and occupational therapists, in cooperation with the individual and his/her family in line with appropriate goals (Wade, 2020). To achieve rehabilitation goals, the focus is not only on the diagnosis, but also on the current health status, developmental difficulty, disability and the impact of the person's physical, mental and psychological potential on their life. It involves working in partnership with the person and their loved ones so that they can maximize their potential and independence and have choice and control over their own lives (NHS England, 2016).

Today, different fields of physiotherapy and rehabilitation and occupational therapy have emerged according to the needs of the individual included in the rehabilitation program, their current problems and the type of disease or diagnosis. The formation of these areas ensures both the specialization of trained health personnel in certain areas and more effective service for individuals in need of rehabilitation. (Figure 1).

Figure 1
Rehabilitation Fields



The principles of rehabilitation applied in almost all of these areas are based on motor learning principles for the acquisition of motor skills. Motor learning occurs through structural and functional development in the neural system, leading to neurobehavioral changes. The neural system transfers the mechanism of movement from conscious-voluntary control to an unconscious control mode. The flexibility and modifiability of cortical reorganization underlies motor learning (Tarakci & Arman, 2019).

Today, new applications and treatment approaches have emerged with the reflection of the rapid development of technology in the field of rehabilitation. Different technological applications and devices are used in the field of rehabilitation to improve the sensory and motor abilities of patients.

The use of technology in rehabilitation offers the opportunity to manipulate the learning environment and achieve a more intense learning experience. Gains in cognition, motor control, emotion and willpower, social, personal and media use competencies can be achieved using technology (Tarakci & Arman, 2019).

Relationship of Rehabilitation Technologies with Neural Systems

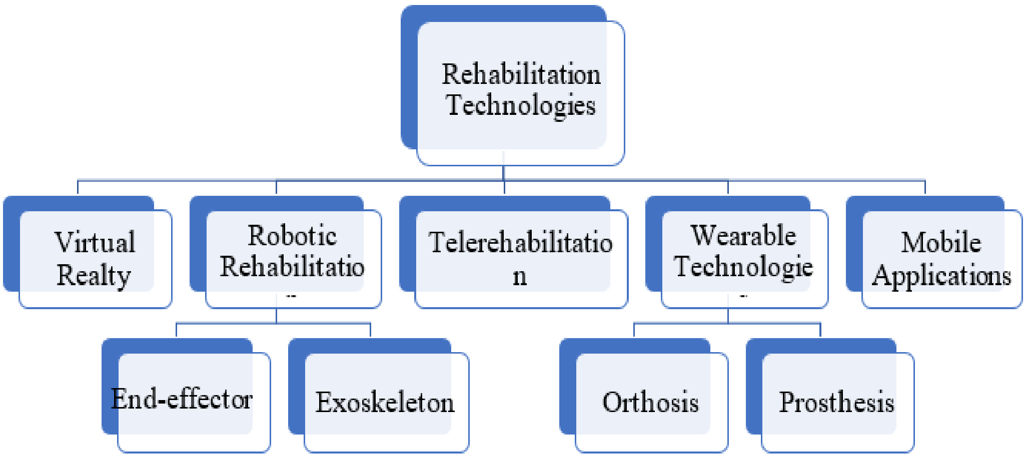
Previously there was the idea that the nervous system was stable and did not change, but in recent years it has been proven that the nervous system has a dynamic structure. Neuroplasticity is the name given to all of the changes in neural organization that occur in the central nervous system throughout an individual's lifetime (Braun & Wittenberg, 2021). The use of technological devices and applications in rehabilitation is based on the principle of motor recovery and neuroplasticity. For this reason, it is seen that the technological approaches used today are mostly concentrated in the fields of cognitive, neurological and pediatric rehabilitation. The neuroplastic property of the central nervous system can be used to fully or partially restore lost function with appropriate rehabilitation programs. Plasticity basically occurs in three types. The first is associated with development in the prenatal period. The second occurs during development after birth. The third type refers to neuronal changes that are present after development. It is shaped by the experiences that occur in the organism (Alia et al., 2017).

There are basic principles of plasticity that emerge with experience. For example, not using a certain brain function can lead to functional impairment, while training for that function can lead to improvement. For plasticity to occur, the activity must occur at certain repetitions, intensities and at certain times. Attention and interaction are also necessary for plasticity to occur (Kleim & Jones, 2008).

Technologies Used in Rehabilitation

Technological approaches used in Physiotherapy and Rehabilitation and Occupational Therapy vary according to the diagnosis, functional level, needs and potential of the individual. Rehabilitation technologies can be used alone or multiple applications can be used together. The most common example of this is virtual reality applications. Virtual reality applications can be used only through the screen or different interference devices, or they can be integrated into robotic devices or wearable devices to increase motor learning and interaction (Cheung et al., 2014). Figure 2 shows the technological approaches commonly used today.

Figure 2
Common Rehabilitation Technologies and Therapy Approaches (Braun & Wittenberg, 2021)



Virtual Reality

Virtual reality, also called virtual environment, is a three-dimensional computer-based simulation that creates a sense of being in any space and enables the perception of various information such as visual, auditory, etc. by the sensory organs. In virtual reality, the user is surrounded by a computer-generated 3D representation. The user can move in the virtual world, see, reach, grasp and reshape it from different angles (Tieri et al., 2018).

The virtual environment aims to take the user out of the physical environment and into an artificial world. The virtual environment can expose the user to visual stimuli through the screen, auditory stimuli through the audio device, haptic (contact), smell and even taste stimuli. The virtual reality device can enable the individual to be reflected in the environment from an egocentric (first person perspective) or alocentric (third person perspective) point of view. In the alocentric perspective, there is a reflection of the person called "avatar" that represents the person in the virtual environment and reflects the interaction, while in the egosentric perspective, the individual can interact with their own point of view in the virtual environment (Tarakci & Hajebrahimi, 2019).

There are hardware and software tools in systems that create virtual reality. These are hardware that provides visual, auditory or tactile stimulation and connects the user to the virtual environment, monitoring and interaction devices (keyboard, mouse, joystick, etc.) that transfer the user's activities to the virtual environment, display systems and software systems (Tarakci & Hajebrahimi, 2019).

The effectiveness of factors such as the number of senses stimulated in virtual reality applications and the level of interaction is called immersion. The immersion level determines the level of the user's involvement in the virtual environment, in other words, the level of isolation from the real environment. Immersion levels are generally classified into three different levels. Systems that provide a virtual environment at the basic level such as monitor, keyboard, mouse are referred to as non-immersive systems. There are also semi-immmersive systems that use larger and higher resolution screens to increase visual stimulation and immersive systems that use screens or devices that completely cover the user's field of view (Figure 3) (Baus & Bouchard, 2014; Slater & Wilbur, 1997).

Figure 3

Immersion Levels in Virtual Reality A: Non-immersive VR system, B: Semi-immersive VR system, C: İmmersive VR system (Baus & Bouchard, 2014)

The Use of Virtual Reality in Rehabilitation

Virtual reality applications are a brain-computer interaction method that provides many sensory and motor activities in a virtual simulation environment. Repetitive activities, which are the basic principle of neuroplasticity and motor learning mechanisms in traditional rehabilitation applications, are integrated into the virtual reality system and presented as simulations or video games. In this way, it is ensured that the individual's motor skills are developed and activities are performed with plenty of repetition. In addition, studies have shown that it plays a more motivating role compared to traditional rehabilitation and exercise practices, allowing activities to be performed for longer periods of time (Hao et al., 2022; Maier et al., 2019). Virtual reality applications have been shown to be effective in improving motor functions in both adults and children and adolescents (Kiani et al., 2023; Ravi et al., 2017).

Virtual reality is used in the rehabilitation of many neurological diseases such as stroke, head trauma, spinal cord injury, Parkinson's, MS, cerebral palsy, spina bifida, as well as in orthopedic rehabilitation for sensory development such as muscle strengthening, balance coordination development and proprioception. In addition, there are studies showing that it has been used in the field of cardiopulmonary rehabilitation in recent years and has positive clinical results such as increased physical capacity and endurance (García-Bravo et al., 2020; Tarakci & Hajebrahimi, 2019). Virtual reality first emerged with the video game industry. Over time, with its use in the field of rehabilitation and increasing scientific evidence of its effectiveness, the number of games with rehabilitation and educational content has also increased. Today, games with different interactions such as activities of daily living, different movement and activity trainings, cognitive trainings have emerged for rehabilitation purposes. The main companies that commercially produce and develop video games and virtual reality devices are Microsoft Kinect, Nintendo Wii, Oculus Rift, Razer Hydra, HTC Vive (Baus & Bouchard, 2014; Braun & Wittenberg, 2021; Tarakci & Hajebrahimi, 2019).

Figure 4

Use of virtual reality in rehabilitation (Stevens Institute of Technology, 2021)

Robotic Rehabilitation

Disability caused by neurological disorders or diseases requires long-term health care, pharmacological and rehabilitative treatments. Rehabilitation is critical to prevent or reduce morbidity in the later stages of the disease (Gardner et al., 1999). Diseases such as stroke, Parkinson's, spinal cord injury, cerebral palsy and MS require similar rehabilitation interventions to address problems such as motor impairments, reduced mobility and independence (Krebs et al., 2008).

The main aim of neurological rehabilitation is to provide normal movement by improving muscle strength and coordination and sensory skills. In doing so, it is aimed to make normal movement permanent by providing cortical reorganization by supporting neuroplasticity. The most important motor learning principles used to ensure neuroplasticity are based on the repetition of purposeful activities in different ways and in large numbers (Kilinc et al., 2019).

Robotic rehabilitation is a current rehabilitation approach that is frequently used in the field of neurological rehabilitation, especially in the last two decades with rapid developments in technology, mechanical, computer, biomedical engineering and health. It is an application that allows the application of different and multiple repetitive exercises necessary for the stimulation of neuroplasticity, especially with motor learning principles (Demirbas, 2019; Kilinc et al., 2019). Robotic devices have many positive effects such as an objective assessment, enabling early patient participation in rehabilitation, spasticity inhibition, task-oriented training, preventing compensation, supporting neuroplasticity development, high dose and intensity training, cognitive rehabilitation, patient motivation, providing feedback to the patient and facilitating the work of physiotherapists and occupational therapists (Laut et al., 2016). It also has limitations such as high cost and the use of patients with certain functional and cognitive levels.

Robotic Rehabilitation devices used in the field of rehabilitation are divided into two as upper extremity robots and lower extremity robots according to the body parts used, and are divided into two as end effector and wearable robot systems according to the production method (Figure 5 and Figure 6).

Figure 5

a. *Lower limb robot system (Kose, 2021) b. Upper limb robot system (Jakob et al., 2018)*

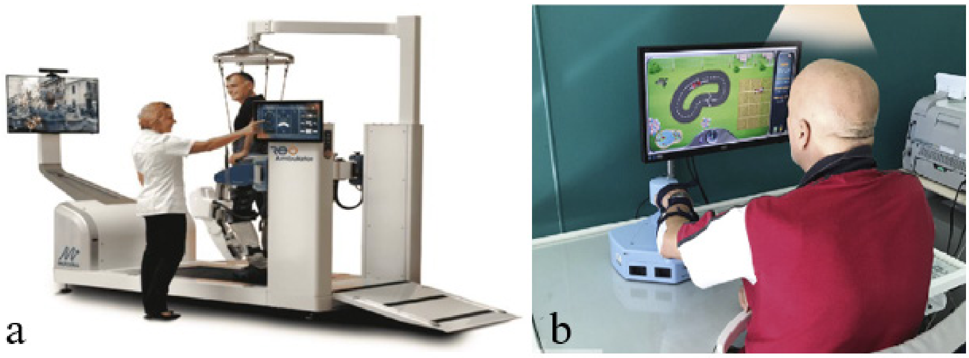
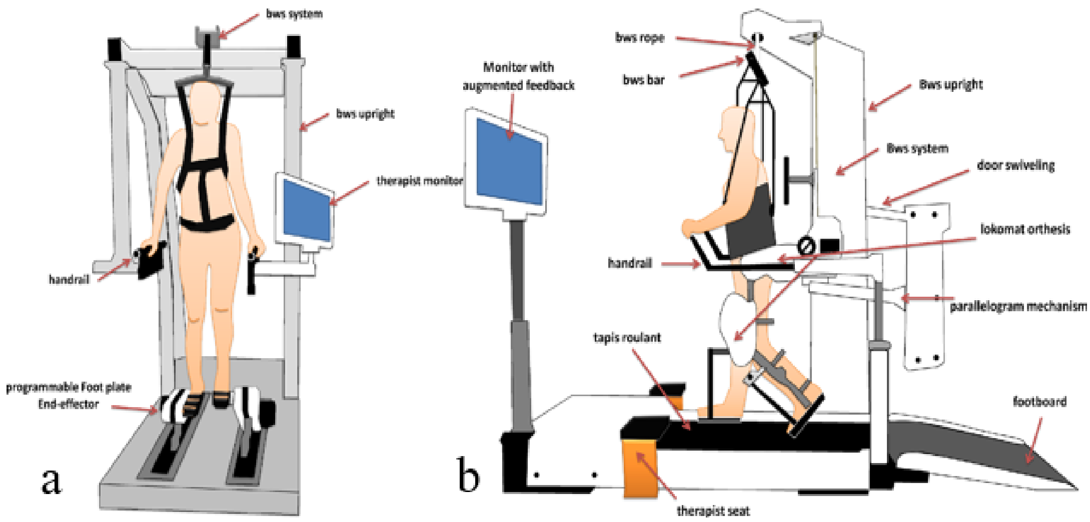


Figure 6

a. End effector robot system, b. Exoskeleton type robot system (Calabrò et al., 2016)



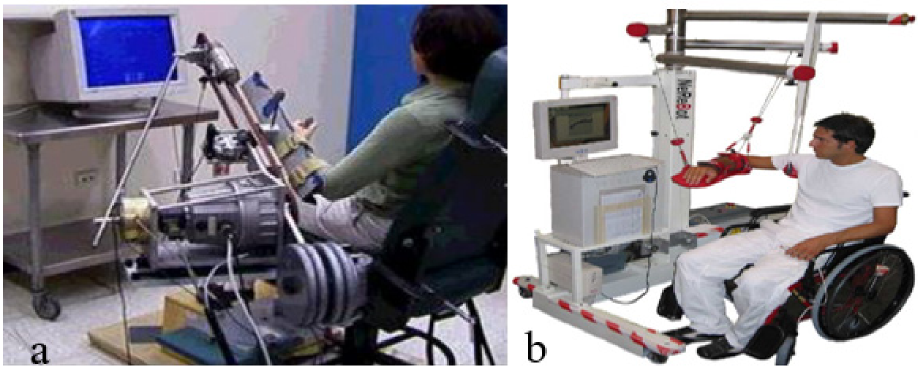
Degrees of freedom (DOF), which is used to express the extent to which joint movements are allowed in robotic rehabilitation devices, determines the axes and planes in which movement occurs (Stegall et al., 2013). For example, a robot has a DOF of 1 if it can only move in one plane, such as hip abduction-adduction. If it performs flexion-extension to the knee and ankle joints in addition to the hip joint, it has a DOF of 3. The increase in the DOF value means that the effectiveness of the robot and its support for movement increases. In general, robotic rehabilitation devices can be used in active modes by supporting movement or creating resistance and passive modes where the device performs the movement completely. In addition, robotic devices can be used with virtual reality systems as a more effective and motivating method (Laut et al., 2016; Weiss et al., 2014).

End-effector Robotic Systems

Upper limb end-effector robots are operated by means of a manipulandum held by the user, while lower limb end-effector robots are operated by means of an interface on the feet or legs. The manipulandum is connected to a robotic arm that transmits forces to the user and contains motion sensors. Since the forces and measurements take place on a single interface, it can be easily adjusted for different users without major changes to the system (Colombo et al., 2005; Mehrholz & Pohl, 2012).

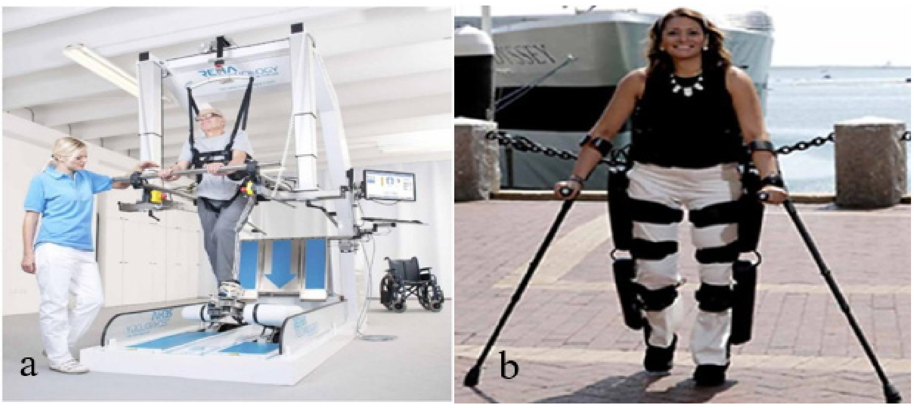
Sensory and motor training using a robotic device is realized through video games controlled by the movement of the manipulandum. The user tries to perform tasks such as drawing shapes or moving along a plane by moving an icon on the screen with the manipulandum. If the user is unable to perform the task, auxiliary force is provided by the robot through the manipulandum (Fasoli et al., 2003; Ferraro et al., 2003). In addition, in some robotic devices, the movements of the manipulandum are converted into kinematic data through sensors, allowing the user's motor functions to be evaluated (Krebs et al., 1998). Arm-Guide, EEULRebot, INmotion, GENTLE/S Haptic Master, NeReBoT, Bi-Manu Track are different end effector robotic device systems used in upper extremity rehabilitation.

Figure 7
a. Arm-Guide (Hidler et al., 2005), b. NeReBoT (Rosati et al., 2007)



End effector robots used for lower extremity rehabilitation are less complex compared to upper extremity movements and are widely used for gait training (Low, 2015). For the lower limbs, robotic systems with force and torque sensors that allow simulation of walking and stair climbing activities are used. At the same time, data can be obtained through these devices that allow the evaluation of gait performance. Especially in neurological and geriatric individuals, it is possible for the therapist to provide walking training safely and with minimal effort against the risk of falling (Hesse et al., 2012; Schmidt et al., 2005). GT, G-EO System, Lokohelp, Rewalk are different end effector robotic device systems used in lower extremity and gait rehabilitation.

Figure 8
a. G-EO System, b. Rewalk (Goncalves et al., 2020)



Exoskeleton Robotic Systems

Unlike end effector robots, exoskeleton-type robots move directly on the user's specific joints. They are generally more difficult to design and build as they need to be adjustable to users of different anthropomorphic sizes and need to be connected to the limb at multiple points. Exoskeletons designed for the upper limb are heavy as they connect to different segments of the user's limb. This requires users to use compensatory muscle strategies during movement (Lum et al., 1999, 2006).

Exoskeletons have the ability to resist or assist movement by applying mechanical force to limb segments. Each joint can move independently of the other joints and isolated or combined joint movements can be performed (Kilinc et al., 2019). Exoskeletons used for lower extremities can have different DOF values from 2 to 8. They are especially used for gait training, balance training and clinical evaluation. There are also body weight support systems in the devices used for lower extremities (Roy et al., 2007, 2013). Hybrit Arm Orthosis, MIT Manus, ARMin, MIME, CLEVERarm, Armeo Power, Asist-On are exoskeleton robotic devices frequently used in upper extremity rehabilitation; Lokomat, ReoAmbulator, LOPES, Anklebot, ALEX, ICRO are exoskeleton robotic devices frequently used in lower extremity rehabilitation.

Figure 9

a. MIT-Manus (Hidler et al., 2005), b. Armeo Power (Sicuri et al., 2014)

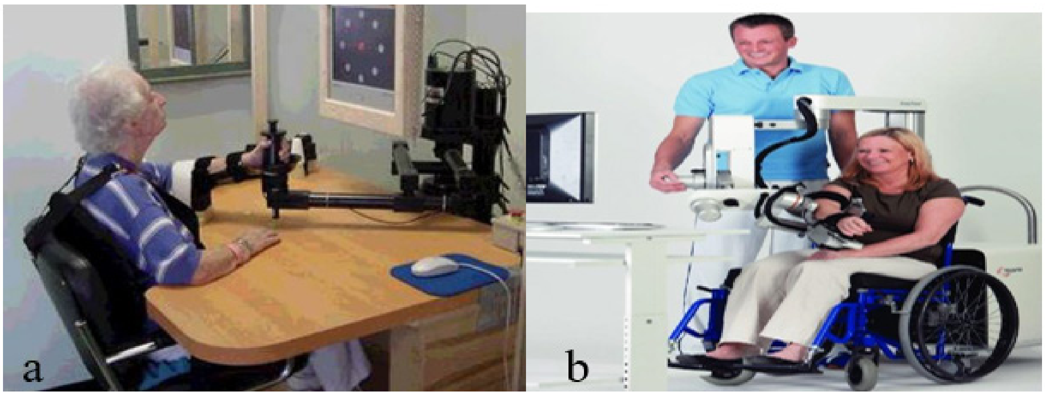
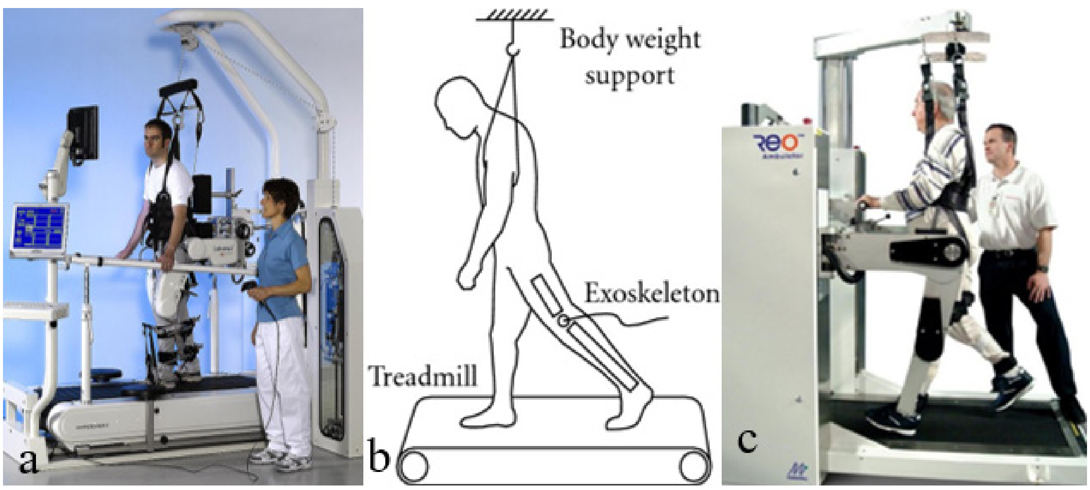


Figure 10

a. Lokomat (Lünenburger et al., 2007), b. Body Weight Support, c. ReoAmbulator (Díaz et al., 2011)



Telerehabilitation

Telemedicine is the remote realization of medical evaluation and treatment methods in a digital environment through technology. Using this technology, clinicians can remotely assess patients and direct treatment. Telemedicine applications are increasingly used today with the development of information technologies. Telerehabilitation, one of the prominent areas of telemedicine in recent years, is the provision of remote rehabilitation services through information and communication technologies (Flodgren et al., 2015; Peretti et al., 2017).

Telerehabilitation has many advantages for all rehabilitation specialties. In particular, it contributes to reducing the long waiting time for rehabilitation services and the necessity of transportation to the clinic. It also reduces the economic burden of health services and the number of days back to work (Sarsak, 2020). Diagnosis, assessment, intervention, goal setting, patient and family education, supervision and consultation are among the services provided within the scope of telerehabilitation (Galea, 2019; Richmond et al., 2017).

Telerehabilitation applications are divided into 3 groups: image-based technologies, sensor-based technologies and virtual reality technologies. Physiotherapists and occupational therapists use these tools to provide repetition, feedback, active participation, guidance and motivation, which are the basic requirements of motor learning (Russell, 2009). Image-based telerehabilitation technologies are realized through video conferencing and are historically considered to be the oldest telerehabilitation method (Delaplain et al., 1993).

With sensor-based technologies, motion data collected by sensors such as accelerometers and gyroscopes and data such as electrocardiogram, blood pressure and blood oxygen content can be monitored (Peretti et al., 2017). In virtual reality-based telerehabilitation systems, three-dimensional virtual environments are created by the computer for the patient to perform the desired movements and motor responses. Rehabilitation professionals can modify these virtual environments in line with the desired treatment goals (Holden, 2005).

When the literature is examined, there are studies showing that telerehabilitation has been successfully applied in neurological, orthopedic, cardiac and pulmonary rehabilitation. In addition, the recent Covid 19 pandemic has affected the whole world as it is a highly contagious disease, putting a serious burden on health systems and causing serious changes in the way of life. The COVID-19 pandemic has brought the importance of telerehabilitation practices to the forefront (Isernia et al., 2022; Kahraman, 2020; Knepley et al., 2021; Suso-Martí et al., 2021).

Mobile Applications

The use of smartphones, which emerged with the developments in technology, has increased significantly in recent years. It is known that there are approximately 3.4 billion smartphone users worldwide. Mobile applications that enter our lives with smartphones offer many different services such as entertainment, communication and information (Derakhshanrad et al., 2021; Namwongsa et al., 2018). Today, one of the most frequently used areas of mobile applications is the field of health. It is seen that the applications offered for use with smartphones and devices are mainly developed for fitness, nutrition, health tracking, wellness, medical education and diagnosis. It is also seen that mobile applications are increasingly used in the field of rehabilitation. Mobile applications used for patient follow-up and evaluation, especially in rehabilitation services, do not seem to be suitable for use for every risk group yet (Oskay et al., 2019).

In the field of rehabilitation, goniometer applications are most commonly used to measure posture and body positions. Mobile applications that are compatible with the objective measurement methods used in the clinic and have validity and reliability have been created (Milani et al., 2014). Applications that can make measurements through sensors in mobile devices can provide information to the user and health professionals by recording many parameters such as step counting, weight, blood pressure, physical activity level, calorie expenditure, heart rate, ECG data (Antypas & Wangberg, 2012).

There are applications that enable the creation and follow-up of the exercise program that patients need, evaluate parameters such as pain and effort, and provide information to the clinician (Bhachu et al., 2014; Van Reijen et al., 2017). As a result, mobile applications used in the field of rehabilitation are used for patient follow-up and evaluation purposes by facilitating the rehabilitation process of patients and clinicians with the data obtained with smart devices.

Evidence for the Use of Technology in Different Rehabilitation Fields

There is a great deal of scientific research in the literature on the use and effectiveness of rapidly developing technology in rehabilitation. In this section, a summary of the literature on the use of technological developments in different diseases and rehabilitation areas is presented. Various studies have been conducted for many different diseases with the virtual reality-based video game model, referred to as exergames in the literature, and compared with traditional rehabilitation approaches. It has been reported that exergames can provide moderate to vigorous exercise and increase the level of physical activity (Benzing & Schmidt, 2018; Klompstra et al., 2014).

Studies, especially in children and young people, show that exercises with exergames increase cardiorespiratory fitness (CRF) and physical activity levels. In addition, participants reported that the video game-based exercise method was more motivating and exercise intensity was perceived to be lower compared to traditional exercise practices (Glen et al., 2017; McDonough et al., 2018).

The prescription use of exergames in patients with heart failure has been associated with significant improvements in energy expenditure and functional capacity based on the 6-minute walk test (6MWT), indicating promising results for clinical application. Exergames has shown that metabolic equivalents (MET), heart rate and oxygen consumption (VO2) can be measured to calculate exercise capacity/CRF (Gomez et al., 2018; Klompstra et al., 2014).

In studies conducted with Nintendo Wii® in individuals with cerebral palsy (CP), it was reported that motor skills increased. In studies conducted with Xbox® Kinect, improvements in gait endurance, upper extremity functions and gross motor skills were reported. There is a strong level of evidence that functional balance and functional mobility improve in children with CP with training with the IREX® system, which is specially designed for rehabilitation (Do et al., 2016; Glegg et al., 2014). In a study that examined the effectiveness of robotic rehabilitation and included 18 individuals with CP, the participants were divided into two groups. The treatment group received conventional physiotherapy and robotic rehabilitation, while the control group received only conventional physiotherapy. It was found that the functional independence results of the patients in the robotic rehabilitation group were higher than the other group (Gilliaux et al., 2015). In another study with 67 participants with CP and a single group, each patient received robotic rehabilitation sessions at least once a week. In the functional independence assessment, a significant difference was found between the measurements at the beginning and end of treatment (van Hedel et al., 2016).

In the literature, there are studies showing that robotic rehabilitation for the lower extremity improves balance, gait parameters and lower extremity muscle strength (Dewar et al., 2015; Tarakci et al., 2020). There are studies showing that upper extremity robotic rehabilitation applications increase motor control, motor activity and function, and decrease pain and spasticity (Takahashi et al., 2016; Tomić et al., 2017). However, some studies have reported that the effectiveness of upper extremity robotic rehabilitation is insufficient and more studies are needed (Taveggia et al., 2016; Veerbeek et al., 2017).

A 2021 review study showed that telerehabilitation had better outcomes compared to face-to-face rehabilitation in patients with low back pain, osteoarthritis, multiple sclerosis and knee-hip arthroplasty compared to control and waiting groups (Seron et al., 2021). In a review study examining the clinical outcomes of telerehabilitation, it was reported that 51% of the results were clinically significant and that telerehabilitation applications enabled more frequent communication with patients (Hailey et al., 2011).

In several studies examining telerehabilitation practices applied to Parkinson's patients, there is evidence that patients' cognitive skills, especially attention, logical, long-term memory and executive functions, have improved (Dias et al., 2016; Quinn et al., 2019). There are studies showing that telerehabilitation has similar efficacy with traditional and face-to-face rehabilitation practices in individuals with stroke (Chen et al., 2015; Schroder et al., 2019). There are studies in the literature showing that telerehabilitation is feasible and reliable in pulmonary rehabilitation and provides similar benefits to face-to-face rehabilitation in reducing dyspnea and morbidity, improving functional capacity and quality of life (Liu et al., 2014; Tsai et al., 2017).

In conclusion, it is obvious that technological developments have brought new ways and applications to rehabilitation approaches today. It is seen that technological applications contribute to more effective access of patients and health professionals to the gains aimed to be achieved through rehabilitation. However, clinical and scientific research shows that there is a need for much more studies on the type, frequency, quality, effectiveness and applicability of technological approaches used in the field of physiotherapy and rehabilitation and occupational therapy.

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Corum, M., Corum, E.N. & Kunduracilar, Z. (2023). Current Technological Approaches in Physiotherapy and Occupational Therapy. In S.N. Guner, Y. Uzun & I. Cetin (Eds.), *Current Studies in Healthcare and Technology* (pp.218–237). ISRES Publishing.

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