Hacettepe University Social Science Institute

Department of Economics

ECONOMIC IMPACTS OF ARTIFICIAL INTELLIGENCE IN HEALTHCARE

Gökçe Nur DURAN

Master’s Thesis

Ankara,2024

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ACCEPTANCE AND APPROVAL

The jury finds that Gökçe Nur DURAN has on the date of 12.01.2024 successfully passed the defense examination and approves her Master's Thesis titled "Economic Impact of Artificial Intelligence In Healthcare".

Assoc. Prof. Dr. Emre ATILGAN (Jury President)

Prof. Dr. Zafer ÇALIŞKAN (Main Adviser)

Assoc. Prof. Dr. Selcen ÖZTÜRK

I agree that the signatures above belong to the faculty members listed.

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ABSTRACT

DURAN, Gökçe Nur. *Economic Impacts of Artificial Intelligence in Healthcare*, Master's Thesis, Ankara, 2024.

Health is a fundamental need for individuals and is also a significant for economic and social development. Health services constitute one of the largest sectors globally. However, today's healthcare systems face various challenges, including a growing population, the prevalence of non-communicable diseases, an aging population leading to an increase in the proportion of patients utilizing healthcare services, and rising costs. Artificial intelligence (AI) technology holds great potential in addressing these challenges. The purpose of this thesis is to highlight the economic impacts of rapidly expanding AI usage in the field of health. In this context, qualitative research methods were employed, and a comprehensive review was conducted using data from various sources such as Pubmed, Google Scholar, ProQuest, Web of Science, Scopus, Science Direct, EMBASE, Dergipark, as well as numerous journals and books. The document analysis technique has been systematically applied at every stage of the study. In this context, the economic impacts of AI utilization in the healthcare have been elucidated comprehensively, incorporating recent studies from a broad perspective. According to the findings of this extensive research, compared to traditional methods, artificial intelligence makes significant contributions to enhancing the quality and efficiency of healthcare services, ensuring effectiveness, and reducing costs. Therefore, this study sheds light on future research on the economic effects of artificial intelligence in the field of health.

Keywords

Digitalization in Health, Artificial Intelligence in Health, Health Economics

ÖZET

DURAN, Gökçe Nur. *Sağlıkta Yapay Zekanın Ekonomik Etkileri*, Yüksek Lisans Tezi, Ankara, 2024.

Sağlık, insanların temel bir ihtiyacıdır. Aynı zamanda ekonomik ve sosyal kalkınmanın da önemli bir temelidir. Sağlık hizmetleri, dünyanın en büyük sektörleri arasında yer almaktadır. Ancak günümüzde sağlık sistemleri; artan nüfus, bulaşıcı olmayan hastalıkların yaygınlaşması, nüfusun yaşlanması sağlık hizmetlerinden yararlanan hastaların oranında meydana gelen artış ve maliyetlerin artması gibi birçok farklı sorunla da karşı karşıyadır. Söz konusu sorunların çözümü için yapay zekâ teknolojisi oldukça büyük bir potansiyele sahiptir. Bu tez çalışmasının amacı, sağlık alanında kullanım alanı ve yaygınlığı hızla artan yapay zekânın ekonomik etkilerini ortaya koymaktır. Bu kapsamda, nitel araştırma metodundan faydalanılmış olup Pubmed, Google Scholar, ProQuest, Web of Science, Scopus, Science Direct, EMBASE, Dergipark gibi verilerin bulunduğu sitelerden, birçok dergi ve kitaplardan kapsamlı bir inceleme ve derleme yapılmıştır. Veri toplamak amacıyla kullanılan doküman incelemesi tekniği çalışmanın her aşamasında uygulanmıştır. Bu kapsamda, sağlık alanında yapay zekâ kullanımının ekonomik etkileri güncel çalışmalar dahil edilerek geniş bir perspektiften gözler önüne serilmiştir. Yapılan kapsamlı araştırma sonucuna göre, geleneksel yöntemlere kıyasla yapay zekanın sağlık hizmetinin kalitesinin ve verimliliğin artırılmasında, etkinliğin sağlanmasında ve maliyetlerin düşürülmesinde oldukça önemli katkılar sunmaktadır. Bu nedenle, çalışma sağlık alanında yapay zekanın ekonomik etkileri üzerine gelecekteki araştırmalara ışık tutmaktadır.

Anahtar Sözcükler

Sağlıkta Dijitalleşme, Sağlıkta Yapay Zekâ, Sağlık Ekonomisi

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LIST OF ABBREVIATIONS

AI	: Artificial Intelligence
BIR	: Billing and Insurance Related
UN CDC	: The United Nations Ageing Program and the Centers for Disease Control and Prevention
CNN	: Convolutional Neural Network
COPD	: Chronic Obstructive Pulmonary Disease
ECG	: Electrocardiograms
EHFCN	: European Healthcare Fraud and Corruption Network
EHR	: Electronic Health Records
EMS	: Emergency Medical Services
FBI	: Federal Bureau of Investigation
FDA	: Food and Drug Administration
GDP	: Gross Domestic Product
HSC	: Healthcare Supply Chain
IBM	: International Business Machines
IDF	: International Diabetes Federation
LIFE	: Life First Emergency Traffic Control
LSTM	: Long Short-Term Memory
ML	: Machine Learning
MR	: Magnetic Resonance Imaging
NATO	: North Atlantic Treaty Organization
NCD	: Non-Communicable Disease
NLP	: Natural Language Processing
PCR	: Polymerase Chain Reaction Test
RCI	: Routine Childhood Immunizations
RNN	: Recurrent Neural Network
SARS	: Severe Acute Respiratory Syndrome
SDG	: Sustainable Development Goals
SNARC	: Stochastic Neural Analog Reinforcement Computer
TÜBİTAK	: Scientific and Technological Research Council of Turkey

OECD	**:** Organization for Economic Co-operation and Development
UHC	**:** Universal Health Coverage
UNDP	**:** United Nations Development Program
WHO	**:** World Health Organization

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INTRODUCTION

Health is a fundamental need for individuals and is also a crucial foundation for economic and social development. On the other hand, health is determined by innate genetic characteristics, lifestyle, socio-economic structure and ultimately health services. Health services rank among the world's largest sectors. However, today's health systems face various challenges, including a growing population and increasing their health care need, the prevalence of non-communicable diseases, an aging population, an increase in the proportion of patients benefiting from healthcare services, and rising costs.

On the other hand, the health care sector is undergoing rapid transformation and digitization, especially with the increasingly central role of artificial intelligence (AI) technology. AI applications in healthcare have a wide range of uses, including the diagnosis and treatment of diseases, drug discovery, radiological imaging, and documentation management in both administrative and clinical services. The goal of this technology is to assist healthcare professionals in making accurate clinical decisions, provide more efficient personalized services to patients, reduce existing costs in the healthcare system, make healthcare services accessible to everyone, and enhance the efficiency of the healthcare system by reducing medical errors (Jayaraman, Forkan, Morshed, Haghighi, & Kang, 2020). The necessity of using this technology is increasingly recognized every day for addressing various problems in healthcare, improving and sustaining quality, increasing efficiency, and ensuring effectiveness (Jiang, et al., 2017).

Due to both the need to address the challenges faced by the healthcare sector and the numerous advantages it offers, investments in artificial intelligence (AI) technology in the healthcare sector are steadily increasing, leading to the expansion of the AI market. While the global AI market in the healthcare sector was known to reach around 11 billion dollars in 2021 and 15.1 billion U.S. dollars in 2022. It is expected to surpass approximately 187.95 billion U.S. dollars by the year 2030. The increase in investments made by both the public and private sectors contributes to the growth of the AI market in the healthcare sector.

The potential of artificial intelligence in healthcare is of enormous magnitude, drawing attention not only from governments but also from technology organizations (STM ThinkTech, 2019). However, despite the rapid adoption of artificial intelligence technology in healthcare by the health care industry and stakeholders, the number of studies considering the effects of artificial intelligence on healthcare in the literature is quite insufficient. This study aims to assess the economic impacts of rapidly expanding artificial intelligence applications in the field of health.

By investigating artificial intelligence applications in healthcare worldwide, an attempt is made to demonstrate that artificial intelligence provides more economical solutions compared to traditional methods. The digitization of healthcare and artificial intelligence technology contributes significantly to enhancing the quality and efficiency of healthcare services, ensuring effectiveness, and reducing costs.

In this thesis study, which discusses the economic impacts of artificial intelligence in the field of healthcare, a qualitative research method has been employed. Document analysis, a technique commonly used for data collection in qualitative research, was applied at every stage of the study.

In this study, firstly, research data terms related to the subject have been provided, and artificial intelligence studies in the field of healthcare have been examined. Definitions of artificial intelligence, its historical background, and data regarding its administrative and clinical applications in the healthcare domain were explored. Subsequently, the economic impacts of the use of artificial intelligence technology in the field of healthcare have been investigated.

During the comprehensive literature review conducted on this thesis, Turkish and English sources were consulted. Access to sources is facilitated through the Open Access System of Hacettepe University and the web services of the National Library. Examination and compilation were carried out from various journals and books available on sites such as PubMed, Google Scholar, ProQuest, Web of Science, Scopus, Science Direct, EMBASE, and Dergipark.

Despite the recent increase in the number of scientific publications, the inadequacy of studies on artificial intelligence applications in the healthcare field in the literature has limited the scope of the research. Existing studies, in terms of evaluating the economic impacts of artificial intelligence, have remained at a limited level.

When examined in the YÖK Thesis Center, it is observed that there is no study investigating the economic impacts of artificial intelligence utilization in healthcare. In order to fill this gap in the literature, an attempt has been made to create a resource that comprehensively examines the economic impacts of AI utilization in the healthcare sector from a broad perspective. This study focuses on the yet-unexplored economic effects of AI utilization in healthcare, contributing to the alleviation of existing knowledge gaps. The extensive research conducted reveals the potential economic impacts of artificial intelligence in the healthcare sector. Thus, this study will be a comprehensive guide for future research endeavors.

CHAPTER 1

THE DEVELOPMENT AND IMPORTANCE OF ARTIFICIAL INTELLIGENCE AND ITS AREAS OF USE

1.1. CONCEPT OF ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI), a subject often portrayed in science fiction films and novels, possesses the potential to shape the future in diverse economic, social, cultural, and political dimensions. It is becoming an increasingly popular field of study worldwide. While the concept of artificial intelligence has been depicted in various ways throughout history, the term 'automaton' was initially used instead. Additionally, the concept of 'tasis,' employed by Aristotle, was also considered as an alternative to the term 'artificial intelligence.' However, in contemporary literature, the term 'artificial intelligence' is frequently used in place of both 'automaton' and 'tasis.'

Although the history of the concept of artificial intelligence spans approximately 2700 years, the modern concept of artificial intelligence is relatively recent. A review of the literature reveals different definitions of the term 'artificial intelligence' in many popular dictionaries.

Firstly, examining the definitions in dictionaries: In the Oxford Dictionary, artificial intelligence is defined as "The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages." The Turkish Language Association defines artificial intelligence as "The ability of a computer, a robot under computer control, or a programmable device to exhibit functions similar to humans, such as perception, learning, reasoning, decision-making, problem-solving, and communication.

In addition to popular dictionaries, many researchers and theorists have provided definitions of the concept of artificial intelligence, containing similarities or differences. One of the most significant figures in the field of artificial intelligence, recognized as a pioneer for his work in the 1950s, is Alan Turing. Turing, with his work on artificial intelligence, made the first definition of the term in the literature by stating, 'If a machine can imitate human responses in a conversation with a human, then that machine can be considered intelligent.' At this point, Turing conducted research on whether the difference between artificial intelligence and a human can be understood using the Turing Test he introduced.

Another definition comes from John McCarthy. In his 1955 work titled “What Is Artificial Intelligence?” McCarthy defined artificial intelligence as “It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.” Another definition was proposed by Alan Newell and Herbert Simon, who stated, “If an artificial intelligence program can solve problems at a level of human-like intelligence, that program is considered artificial intelligence.” In Ray Kurzweil's definition of evolutionary artificial intelligence, artificial intelligence is described as machines and algorithms that attempt to model and eventually surpass human intelligence.

According to Stuart Russell and Peter Norvig, “Artificial intelligence is the emulation of human intelligence through computers and other machines. It particularly involves understanding thought processes, solving various types of problems, interpreting language meaning, and learning.” (Russell & Norvig, 2023).

In addition, artificial intelligence has been defined by the OECD as “A machine-based system” that can, for a given set of human-defined objectives, make predictions, recommendations, or decisions influencing real or virtual environments. AI systems are designed to operate with varying levels of autonomy. In addition, AI is defined as “machines performing human-like cognitive functions” (OECD, 2019).

Finally, to understand how artificial intelligence defines itself, the question “What is Artificial Intelligence?” was posed to ChatGPT, and the response received was: 'Artificial intelligence (AI) refers to the field where computer systems attempt to mimic or simulate capabilities similar to human intelligence. This field aims for computers to perform human-like activities such as thinking, learning, problem-solving, and decision-making. Artificial intelligence is a discipline that encompasses different methods, including algorithms, data analysis, statistics, pattern recognition, and learning techniques.

1.2. HISTORICAL DEVELOPMENT OF ARTIFICIAL INTELLIGENCE

When examining the historical background of artificial intelligence, a field that finds applications in numerous disciplines today, one encounters the first instances of artificial intelligence myths in Ancient Greece in the literature. Regarding these myths, Adrienne Mayor, an Ancient Science Historian, notes that the idea of creating artificial life and robots manifested itself in ancient myths long before technological developments made the construction of self-moving devices possible (at least 2,700 years ago). Mayor even suggests that the earliest concepts of artificial intelligence, robots, and self-moving objects appeared in the works of ancient Greek poets Hesiod and Homer, who lived between 750 and 650 BC, in myths that centered around Talos, a giant made of bronze protecting the island of Crete by hurling rocks at approaching enemies, Pandora, an artificial woman, and their creator, the god Hephaestus.

Similarly, in Chinese history during the 9th century BCE, associated with King Mu, and in a source written in the 3rd century BCE, there is mention of an inventor named Yan Shi gifting an automaton to this ruler, believed to be magical, which was subsequently broken by guards. From such instances, it can be inferred that in many myths involving artificial intelligence, there is often an unfavorable outcome, raising the question of whether the development of artificial intelligence, which still awaits solutions today, is ultimately beneficial or detrimental to human history.

Historically, during the Ancient Roman era, automatons were largely used for entertainment purposes, resembling toys. Developments based on models from the Greek and Roman periods were implemented and improved upon in the Byzantine Empire and subsequently in Muslim territories. However, when viewed from a historical perspective, it is considered more accurate to search for the origins of today's artificial intelligence not in legends and the earliest entertainment-oriented automatons, but rather in the development of systematic thought.

Ancient Greek philosophers made significant strides on the path of this development. In the years 384-322 BCE, Aristotle introduced the concept of “Tasım” developing an original theory of knowledge and a mechanical thinking method (Journo, 2023). It is claimed that elements introduced by Aristotle were rediscovered and developed by Muslim thinkers starting from the 8th century, leading to the emergence of the concept of artificial intelligence. In this context, the 9th-century achievements of Al-Khwarizmi in algebra and algorithms, and the 13th-century inventions of Al-Jazari, including a programmable humanoid automaton, were considered pivotal moments in the history of artificial intelligence. Apart from Harezmi and Cezeri, Banu Musa brothers of Persian origin, İbn-i Heysem and Takiyuddin also worked.

Concrete developments in the modern sense of the concept of artificial intelligence date back to the 17th century. During this period, there was a competition across all segments of society, especially among the ruling and aristocratic classes, to create automatons[1] that imitated human and animal behaviors. This competition was reflected in the philosophical perspective of the time. Renowned philosopher Descartes (1596-1650) likened humans to machines operated by clock-like mechanisms.

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[1] Long before the word "robot" was invented, such inventions were expressed with the concept of automaton.

After this period, the British mathematician Charles Babbage (1792-1871) aimed to imitate mental attributes rather than physical ones, developing the first computing machine called the 'Difference Engine.' Babbage's designed machine, using the finite differences method, was capable of accurate calculations up to 31 digits. The machine, which he envisioned as 2.5 meters tall, weighing 15 tons, and consisting of 25,000 parts, was designed to mimic human mental characteristics. Babbage's computation machine, representing a significant step forward in the context of artificial intelligence studies for its time, was considered a groundbreaking initiative (Schultz & Schultz, 2007). Additionally, during this period, figures such as Ramon Llull, Gottfried Leibniz, Jonathan Swift, Samuel Johnson, Ada Lovelace, George Boole, Richard Millar Devens, and Nikola Tesla laid the foundations of modern artificial intelligence.

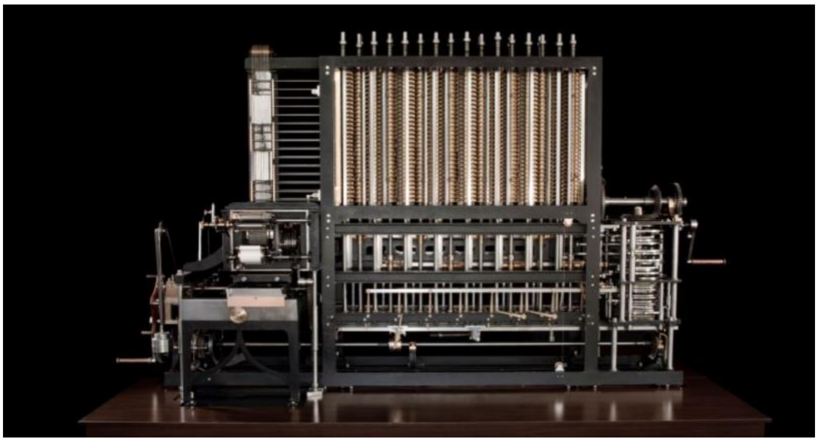


***Figure 1**:Difference Engine*

The acceleration in the development of artificial intelligence in the modern sense took place in the 20th century. In 1914, Spanish engineer Leonardo Torres Quevedo developed the first chess artificial intelligence capable of playing out the endgame against a king and rook without human intervention, although it did not cover the entire game. In the 1920s, Wilhelm Lenz and Ernst Ising designed the first recurrent neural network (RNN), attempting to mimic neurons in the brain. However, this RNN architecture did not possess the capability of "learning." The ability to learn in RNNs was introduced by Shunichi

Amari in 1972. In the subsequent years, RNNs played a central role in speech recognition and language processing techniques.

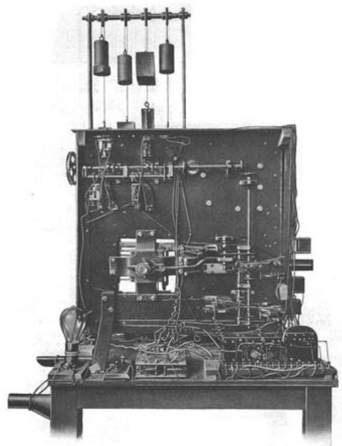


Figure 2:*Torres's First Chess Automat*

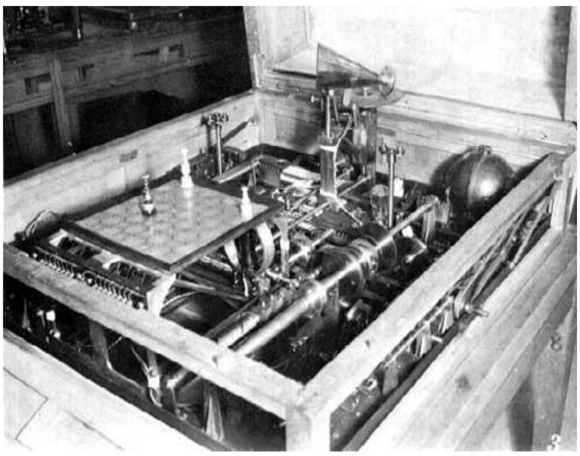


Figure 3:*Torres's Second Chess Automat*

Despite the emergence of some studies, the significance of artificial intelligence (AI) research in the modern sense gained prominence during and after World War II. Alan Mathison Turing, during the Second World War, changed the course of the war by inventing the first fully automatic code-breaking machine called "Bombe", which could be considered significant within the conditions of that time (Acar, 2020). After World War II, many researchers, including Alan Turing, independently started working on artificial intelligence. In 1947, Alan Turing gave the first conference on artificial intelligence, explaining that intelligent machines could be invented by combining artificial intelligence and computer programs (McCarthy, 2007). In 1950, Turing published the article "Computing Machinery and Intelligence," where he discussed the question, "Can machines think?" (Turing, 1950). Using the combination of the words "machine" and "thinking" as a starting point, Turing laid the conceptual foundations of artificial intelligence (Turing, 1950). Additionally, in 1950, Turing introduced the Turing Test, aiming to test whether a human could discern the difference between an artificial intelligence and another human.

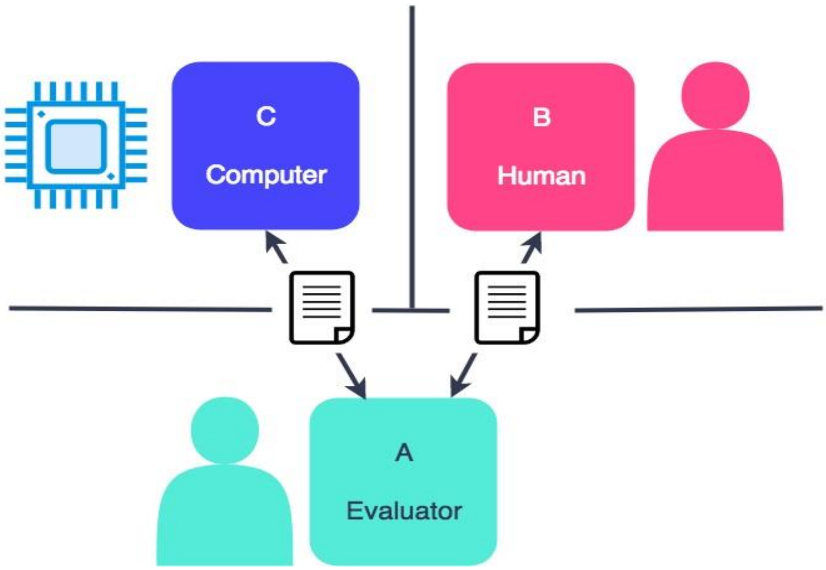


Figure 4:*Image of Turing Test*

Claude Shannon, one of the founders of modern information theory, aimed to develop a chess-playing computer program with his work "Programming a Computer for Playing Chess" in 1950 (Shannon, 1950). In 1951, Marvin Minsky and Dean Edmunds constructed the first artificial neural network structure called SNARC (Stochastic Neural Analog Reinforcement Computer).

Although Alan Turing is considered the father of artificial intelligence, the term "artificial intelligence" was first used in 1956 at a workshop on artificial intelligence organized by John McCarthy at Dartmouth College. In addition to John McCarthy, important names in the field such as Marvin L. Minsky (Massachusetts Institute of Technology-MIT), Nathaniel Rochester (International Business Machines-IBM) and Claude Shannon (Bell Laboratories) took part in this event (Dick, 2019). Following this workshop, significant developments occurred in areas such as big data, smart algorithms, machine learning techniques, and deep neural networks, accelerating artificial intelligence research. Subsequently, in 1955, Herbert Simon and Allen Newell developed the first artificial intelligence program, the Logic Theorist, proving 38 of the first 52 theorems in Russell's Principia Mathematica. Later, important artificial intelligence programs such as Aziz (1961), Benzeşim (1963), Eliza (1965), Bilgin (1970), and Stajyer (1979) were developed (Kutlusoy, 2019). The first humanoid intelligent robot, WABOT-I, was introduced in Japan in 1972 (Acar, 2020).

Science fiction master Isaac Asimov, the creator of the Three Laws of Robotics, shared his predictions about the future of artificial intelligence with The New York Times in 1964. Asimov foresaw, “If machines are this intelligent today, what could happen in 50 years? Miniaturized computers will serve as the 'brain' of robots. Communication will be visual and vocal; you'll be able to see and hear the person you're talking to on the phone. Screens will be used not only to see the people you call but also to examine documents, view photos, and read quotes from books.” Herbert Simon predicted in 1965 that “within twenty years, machines will be able to do any job a human can do.”

As the concept of artificial intelligence gained visibility and discussion initially, countries began to make more investment decisions in the field of artificial intelligence. However, over time, in contrast to the positive studies on the development of artificial intelligence, many publications negatively criticized artificial intelligence research, in the period between 1974 and 1980. Some states, influenced by these articles, stopped allocating funds to artificial intelligence projects. This period is referred to as the “Artificial Intelligence Winter.”

In the 1980s, the field regained momentum with the UK allocating funds for AI research to compete with Japan (Öztürk & Şahin, 2018). By the 1990s, some thinkers expressed pessimistic views about the development of artificial intelligence. For instance, Hubert Dreyfus, in his work titled 'Alchemy and AI,' argued that the mind is not like a computer and that there will always be limits to artificial intelligence. I.J. Good, in his essay 'Speculations Concerning the First Ultra-Intelligent Machine,' stated, 'The first ultra-intelligent machine will be the last invention that man needs to make, provided that the machine is docile enough to tell us how to keep it under control.' In 1993, Vernor Vinge, in his work 'The Coming Technological Singularity,' claimed that we would achieve technologies capable of creating superhuman intelligence within thirty years, stating, 'Shortly after, the era of humanity will come to an end.

In addition to these pessimistic assessments, undoubtedly, some of the most significant advancements in the concept of artificial intelligence emerged during the same period. Examples include Tim Berners-Lee initiating the development of a client program for a browser/editor named Worldwide Web on his NeXT computer and Larry Page and Sergey Brin, both doctoral students in the computer engineering department at Stanford University in 1996, developing the algorithm for the Google search engine.

A noteworthy event occurred in 1997 when the program named "Deep Blue," produced by IBM, defeated the world chess champion Garry Kasparov in a chess match. Garry Kasparov competed against a program capable of processing 200 million chess moves per second and suffered defeat. This event highlighted those computers could outperform humans in certain domains (Schultz & Schultz, 2007).

In the early 2000s, artificial intelligence entered households for the first time with the introduction of the electric vacuum cleaner named "Roomba." By the year 2006, major companies such as Facebook, Netflix, and Twitter had begun utilizing artificial intelligence (Acar, 2020). In 2011, IBM's Watson program defeated human competitors in the game show 'Jeopardy!' in the United States and 'Big Risk' (Büyük Risk) in Turkey (Sarıel, 2017). Also in 2011, Apple launched a personal assistant and information navigation service named Siri with the iPhone 4S model. Siri allows users to ask questions and give commands in natural language. In 2014, Facebook published an article about the DeepFace facial recognition system, which employed deep learning techniques capable of recognizing faces with high accuracy, reaching human-like precision levels.

The research laboratory called OpenAI, which is widely talked about today, was established in the USA in 2015. In 2018, Google introduced the Duplex program, which successfully made hair salon appointments over the phone without revealing it was a machine (Acar, 2020). Most recently, in 2022, Meta, the parent company of Facebook, introduced Blenderbot 3 as an alternative to OpenAI's GPT-3, utilizing its own artificial intelligence model. OpenAI, in turn, made the GPT-3 language model available for global use through the conversational robot named ChatGPT. In March 2023, the GPT-4 version was released, allowing the model to accept not only textual but also visual inputs. In the present day, expert systems employing artificial intelligence have reached a level where they can provide recommendations to doctors. Additionally, in several states in the United States, autonomous vehicles under artificial intelligence control have started to be employed.

1.3. TYPES OF ARTIFICIAL INTELLIGENCE

Artificial intelligence, defined as the emulation of human cognitive processes such as learning (rules for using knowledge and methods of acquiring knowledge), reasoning (using rules to approach definite conclusions), and self-correction by machines and computer systems, is examined in three distinct categories: "Narrow Artificial Intelligence," "Artificial General Intelligence," and "Artificial Superintelligence." These categories are detailed below.

- **Narrow Artificial Intelligence:** Type of artificial intelligence that performs well only in a predefined, specific task and is widely used today (Girasa, 2020). Due to being trained solely for a particular task, Narrow AI cannot exhibit performance beyond its domain or constraints. It is possible to encounter the term 'weak artificial intelligence' in the literature to describe this characteristic. Examples of this type include the facial recognition technology and Siri assistant found in iPhone phones, IBM's Watson supercomputer frequently utilized in the health sector through a combination of machine learning and natural language processing in an expert system approach, as well as the autonomous driving vehicles of Audi and Tesla, and systems playing chess.

- **General Artificial Intelligence:** Type of artificial intelligence developed with the goal of exhibiting behaviors closer to human intelligence and being capable of thinking like a human. Within this framework, general artificial intelligence possesses general intelligence and intellectual abilities similar to humans. Artificial General Intelligence aims to understand the human mind, emotions, and thoughts, seeking to learn and solve problems in a manner similar to humans (Girasa, 2020). Currently, systems with intelligence equivalent to that of humans do not exist, causing them to perform simple tasks more slowly than humans. Nevertheless, contemporary researchers worldwide are focused on the development of systems endowed with general artificial intelligence (Cao, 2020). An example of this category is the "K Computer" developed by Fujitsu.
- **Superior Artificial Intelligence:** This category refers to a type of artificial intelligence that surpasses human intelligence and is capable of solving any task with cognitive features better than humans. For this reason, the risks of using artificial intelligence come to the forefront. For instance, the misuse of artificial intelligence for malicious purposes, such as in weapons, can lead to control issues (providing unclear goals or instructions to artificial intelligence) and unpredictable outcomes (such as an autonomous vehicle traveling as fast as possible without considering safety or traffic rules) (Wimoolka, 2022). Concerns have arisen regarding the controllability of artificial intelligence. In order to mitigate these risks, the implementation of legal regulations related to artificial intelligence is crucial (Allen & Helms, 2006). An illustrative example of Artificial Superintelligence encountered in science fiction films is the portrayal of 'robots' capable of independent thought processes and autonomous motion without relying on human commands.

Artificial Intelligence aims to mimic human cognitive functions and, in doing so, typically perform activities that can be carried out by a human (Jiang, et al., 2017). Human cognitive function is versatile, utilizing necessary inputs such as knowledge, experience, and, in some cases, vision as part of the thought process to generate a thought or decision. In contrast, Artificial Intelligence is also versatile, simulating each input of cognitive function. Many studies within the field of Artificial Intelligence focus on top-level categories such as Machine Learning (ML), Bayesian networks, Natural Language Processing (NLP), and Computer Vision, due to their dominance in this overview field and applicability to the medical field (Ritter, 2019).

Artificial Intelligence consists of various algorithms divided into three main components. Machine Learning and Deep Learning, which are subcomponents of Artificial Intelligence, are the most commonly used methods (Aryal, 2021). These methods are primarily employed by researchers, businesses, and government agencies to make predictions, solve problems, and make decisions by continuously analyzing data according to a specific logical structure. Artificial Intelligence technologies like Machine Learning and Deep Learning learn from large amounts of data to make predictions, solve problems, and make decision (Challen, et al., 2019). Furthermore, Machine Learning and Deep Learning are implemented through learning algorithms fed by computers or machines using statistical techniques (O'Neill, 2017). Various artificial intelligence tools exist, such as expert systems, case-based reasoning, constraint programming, and neural networks (Qureshi, et al., 1998). Common artificial intelligence tools for automation include knowledge-based systems, automated knowledge acquisition, fuzzy logic, genetic algorithms, and ambient intelligence (Sanders & Gegov, 2013).

1.3.1. Machine Learning (ML)

The discipline of Machine Learning, a subfield of Artificial Intelligence, was initially defined by computer scientist and AI pioneer Arthur Samuel in the 1950s as the 'field that gives computers the ability to learn without being explicitly programmed' (McCarthy & Feigenbaum, 1990). Simply put, machine learning is considered a branch of artificial intelligence that focuses on using data and algorithms to mimic how humans learn, gradually improving accuracy over time. Machine learning enables the creation of algorithms that can learn and predict. Unlike rule-based algorithms, it also has the advantage of exposure to large and novel datasets. Additionally, it possesses the capability of development and learning beyond mere experience (Choy, et al., 2018). It teaches computers to learn from data, describe patterns, and make predictions independently. Similar to human processes, it examines data and utilizes it to solve complex problems. The primary goal of machine learning is to extract information from data and solve problems without explicit human intervention. The development and learning capability inherent in machine learning allow for a progressive increase in accuracy over time.

To effectively implement learning from data, it is necessary to collect sample cases and relevant input parameters. This characteristic of machine learning requires the data used to train the model to be of sufficient size and quality (Domingos, 2012). Regardless of the differences in learning tasks, machine learning techniques often attempt to mimic nature based on the knowledge and experience accumulated by humans since their existence. Machine learning techniques draw inspiration from the functioning of the human brain, processes involved in human evolution, theories of human information acquisition and reasoning, and sociological theories behind human behaviors (Min, 2010).

While the terms machine learning and artificial intelligence are often used interchangeably, they fundamentally have some differences. Artificial intelligence refers to the general ability of computers to mimic human behavior and perform tasks, whereas machine learning refers to the algorithms and technologies that enable systems to analyze data and make predictions.

The advancements in machine learning (ML) techniques have led to the widespread use and popularity of artificial intelligence (AI) in various sectors, including health care, automotive, finance, and banking (Aryal, 2021). For instance, voice assistants such as iPhone Siri and Amazon Alexa utilize speech recognition enabled by machine learning algorithms. This technology is also employed in product recommendations on e-commerce websites and chatbots for customer support.

Machine learning, which is increasingly popular and widely used in the field of health care, encompasses various statistical, probability, and optimization techniques. Machine learning enables computers to learn from existing data, rapidly detecting patterns within complex and large datasets. Due to this capability, machine learning is extensively used in diagnosing and prognosis many diseases (Cruz & Wishart, 2006). Additionally, A. Becker, in a 2019 article, examined some of the latest applications of machine learning in medicine in four specific categories. These categories include assessing and predicting the risk of disease onset, using machine learning in the management or mitigation of complications, its role in ongoing patient care, and evaluating the effectiveness of ongoing treatments (Becker, 2019). This situation allows governments to save on public expenditures and make improvements in the delivery of public services (Saxena, Brault, & Rashid, 2021). Big Data and Artificial Intelligence for Healthcare Applications (CRC Press).

Supervised Learning, Unsupervised Learning, and Reinforcement Learning are the three categories of ML. Here, the supervised method is a result-oriented approach compared to other classified methods. This is because it aims to reach information and targets from data and finalize the outcomes (Koyuncugil & Özgülbaş, 2009).

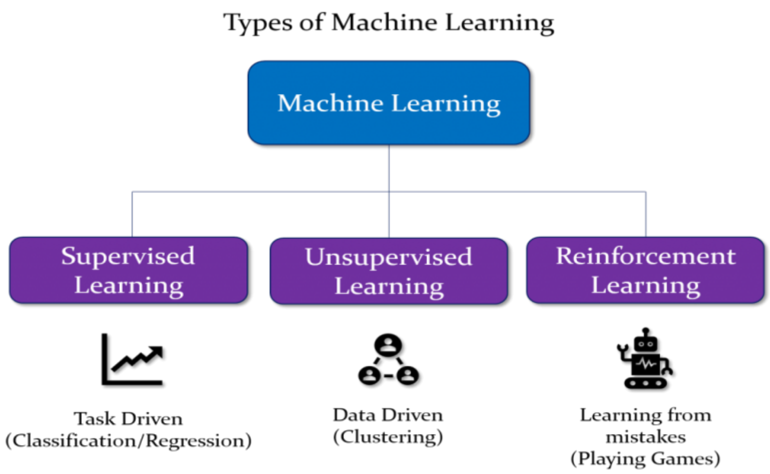


Figure 5: *Machine Learning Types*

a) **<u>Supervised Learning</u>**: Supervised learning is the most widely used and popular method in machine learning. Supervised machine learning is a significant category that relies on existing labeled input-output paired data to be trained in accurately mapping an input to its corresponding output. A supervised machine learning model trained in this way can then be used to predict the output of unlabeled input data (Aryal, 2021). To summaries briefly, each training label produces an output label. The system is trained through labeled data, allowing the system to learn patterns. The acquired knowledge is then utilized to predict values based on subsequent input data (Nilsson, 2009). When making predictions, regression or classification methods are employed. For instance, in detecting if an incoming email is spam, this method requires feeding the machine learning algorithm with significant examples classified as spam for it to learn. This method is the most suitable for use in the health sector as it clinically produces the most optimal results (Jiang, et al., 2017). Currently, supervised machine learning algorithms are used extensively in cardiovascular medicine for preventive, diagnostic, and therapeutic purposes.

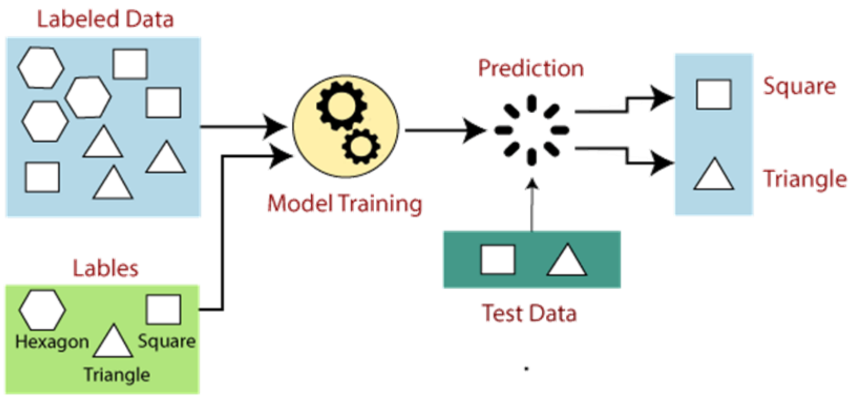


Figure 6:*Supervised Learning Procedures*

b) **Unsupervised Learning**: Unsupervised machine learning is employed to define fundamental data models or relationships between variables without pre-existing labels and significant human oversight (Aryal, 2021). Algorithms attempt to discover a unique model or feature without prior awareness of past experiences. Mathematically, this type of learning occurs when the model has an input (X) but lacks a corresponding output. This learning is termed 'unsupervised learning' as the machine or system itself discovers the response to the input (Shaikh, Krishnan, & Thanki, 2021). Therefore, unsupervised learning can be considered as a process where features can be extracted, and patterns examined without human feedback (Jiang, et al., 2017).

In unsupervised learning algorithms, there is technically no learning taking place due to the absence of an output variable to predict or classify (Shmueli, Bruce, Yahav, Patel, & Lichtendahl Jr., 2017). Data Mining for Business Analytics: Concepts, Techniques, and Applications in R.). While supervised learning involves automatically learning the relationship model between a set of descriptive attributes and a target attribute, unsupervised learning techniques are used in cases where the target attribute is absent. This learning method is typically applied in various fields such as speech and pattern recognition, robotics, autonomous vehicles, and cardiovascular medicine (unlabeled data).

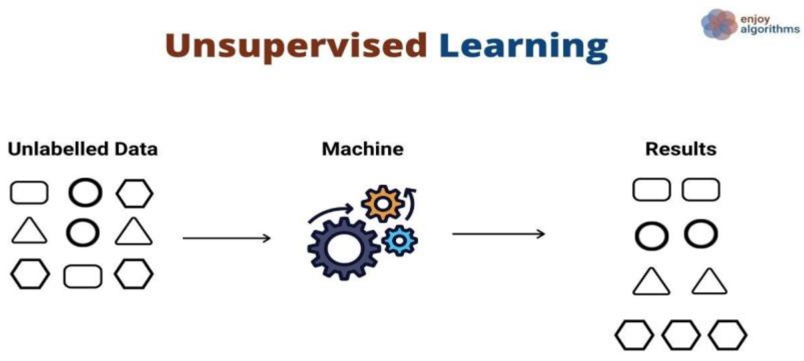


Figure 7:*Unsupervised Learning Procedures*

c) **Reinforcement Learning:** Reinforcement learning, which differs from other types of machine learning, is employed to maximize algorithm accuracy by combining supervised and unsupervised learning (Krittanawong, Zhang, Wang, Aydar, & Kitai, 2017). Defined as learning through trial and error, with feedback in the form of rewards or penalties for algorithm actions, this type of learning involves the machine or system taking specific actions to maximize the output for a given input. Reinforcement learning is a type of learning where parameters are updated to maximize rewards and minimize penalties. Consequently, the best actions are learned in reinforcement learning methods to achieve optimal results (Nilsson, 2009).

Reinforcement learning is widely used in the gaming world and robotic applications. On the other hand, while studies on the application of reinforcement learning to health research are still in the early stages, it has begun to assist doctors in clinical trials. For instance, a reinforcement learning model was used to determine the optimal choice for sepsis treatment, and the findings revealed that treatment outcomes with the reinforcement learning model outperformed those of human clinicians (Komorowski, Celi, Badawi, Gordon, & Faisal, 2018).

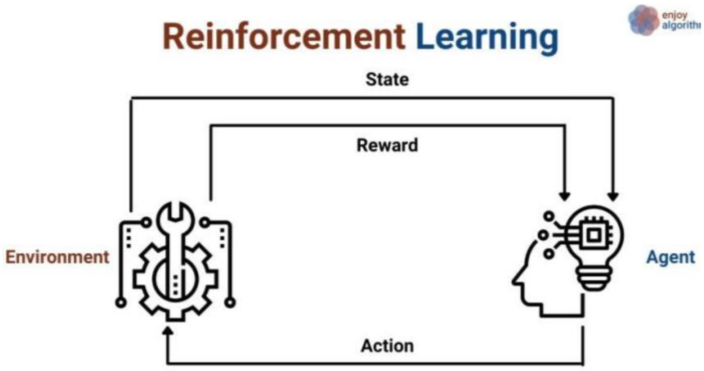


Figure 8:*Reinforcement Learning*

1.3.2. Deep Learning

Deep Learning, a prominent and evolving sub-discipline of artificial intelligence, has made significant progress and gained attention in solving various complex problems. Its recognition in the scientific community began in 2012 when it played a crucial role in winning the Large-Scale Visual Recognition Challenge. Deep learning is a subset of machine learning. Machine learning is also a subset of artificial intelligence that executes intelligent applications. So, all machine learning applications are characterized as artificial intelligence (Aylak, Oral, & Yazıcı, 2021). Today, Deep Learning outperforms many traditional machine learning algorithms in tasks where they fall short (Jiang, et al., 2017).

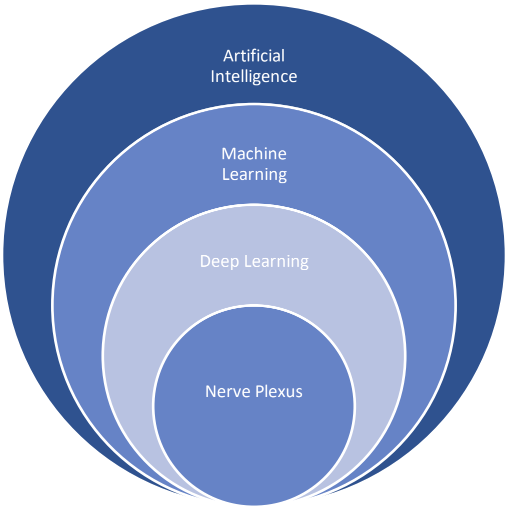


Figure 9: Artificial Intelligence/Machine Learning/Deep Learning

Deep Learning is an extension of multi-layered artificial neural networks, allowing for the exploration of more complex and nonlinear data patterns in a highly detailed manner by mimicking the processing of the human brain with a neural network consisting of many layers (Krittanawong, Zhang, Wang, Aydar, & Kitai, 2017). The term "deep" in deep learning is given due to its multi-layered neural network.

The emergence of deep learning has led to its application in various fields such as image analysis, sound analysis, robotics, autonomous vehicles, genetic analyses, cancer diagnoses, and virtual reality. The primary reason for its widespread use in such diverse areas is its high accuracy in problem-solving. In fact, it has surpassed human performance in some problems such as speech recognition and image identification, leading to its rapid adoption worldwide and finding a widespread commercial use.

Therefore, deep learning is extensively utilized by global giants like Google, Apple, Microsoft, Amazon, and Facebook. For instance, Facebook employs deep learning in facial recognition, and Apple uses it in the Siri application.

Deep learning is frequently employed in image-intensive fields within the healthcare sector, such as radiology, radiotherapy, pathology, ophthalmology, dermatology, and image-guided surgery. Li et al. have developed a resilient deep learning method in their study aimed at improving the diagnosis of Alzheimer's patients and those with mild cognitive impairment (Li, Thung, Ji, Shen, & Li, 2015). In their research, Yu et al. examined the classification problem of digestive organs for wireless capsule endoscopy (WCE) images, aiming to save doctors' review time (Yu J.-s. , Chen, Xiang, & Zou, 2015). A hybrid convolutional neural network with extreme learning machine for WCE image classification, 2015 IEEE International Conference on Robotics and Biomimetics (Yu J.-s. , Chen, Xiang, & Zou, 2015). Both studies achieved successful results. In many cases of interpreting images by deep learning systems, it has been observed that these systems outperform expert doctors, providing an advantage in terms of efficiency and savings (Keleş, 2018).

1.3.3. Natural Language Processing (NLP)

Natural Language Processing (NLP) is an artificial intelligence tool that employs computer algorithms to identify basic components of everyday language. It enables computers to understand, interpret, generate, and respond to human language. NLP builds systems capable of understanding texts and performing tasks such as translation, grammar checking, or topic classification. The foundations of this technology were laid in the Georgetown IBM experiment conducted in 1954. This pioneering experiment facilitated the automatic translation of over 60 sentences from Russian by computers (Hutchins, 2004).

In addition to these, NLP has numerous application areas encountered in our daily tools, possibly without even realizing it. NLP is commonly used in applications such as correcting spelling errors, computerized voice interactions, cross-language translation, speech-to-text conversion, text-to-speech synthesis, and intelligent chatbots (Adalı, 2016). Even in everyday life, social media applications like Twitter, Facebook, Instagram use NLP technology for tasks such as translating posts in different languages or providing text suggestions while filtering unwanted emails into the spam folder.

One of the application areas of Natural Language Processing technology is the healthcare sector. Through NLP technologies, especially disease diagnosis and offering more effective treatment methods to patients become possible. Recently, a US-based healthcare organization utilized NLP technologies to diagnose over fifty thousand patients with aortic stenosis within minutes. This screening, which would take years with manual methods, achieved an extraordinary speed thanks to NLP (McNemar, 2022). As long as artificial intelligence continues to be used in healthcare services and investments in such new technologies persist, we can expect significant advancements in healthcare services, scientific research, and disease diagnostic methods in the near future.

NLP also encompasses components such as Computer Vision, Speech Processing, Recommendation Systems, Reinforcement Learning, and Cognitive Computing. These components are fundamental dynamics used to perform various tasks of Artificial Intelligence.

1.4. USAGE AREAS OF ARTIFICIAL INTELLIGENCE

With the continuous advancement of technology and digital transformations, the concept of artificial intelligence (AI) has begun to permeate every aspect of our lives. By offering smarter, more efficient, and innovative solutions, AI transforms business processes and is frequently used in sectors that directly impact everyday life, such as healthcare, education, finance, automotive, and banking. The applications of AI in these sectors are expanding rapidly, and artificial intelligence is becoming a fundamental element of the future business world. AI systems that determine the most suitable route for finding any address, applications that create personalized recommendation lists for shopping, and AI-based autonomous vehicles that minimize the risk of accidents on highways are just a few examples of AI products that provide significant advantages to individuals in terms of time, effort, cost, and workforce (Sarıel, 2017).

1.5. CONCERNS ABOUT ARTIFICIAL INTELLIGENCE

Since the inception of the idea of artificial intelligence (AI), there has always been the thought that one day these systems could spiral out of control and bring about the end of humanity. The question of whether AI has limits and whether it poses a danger to humanity has been a continuous subject of debate.

Concerns, particularly in the moral and ethical dimensions, are frequently encountered regarding artificial intelligence, which has spread to almost every aspect of our lives. In 1965, mathematician I.J. Good, a collaborator of Turing, published an article titled "Speculations Concerning the First Ultra-intelligent Machine." In this article, he speculated that as machines' intelligence and skills increase in various fields, the resulting 'intelligence explosion' could lead to vast changes in the world order that we cannot foresee or control, and he stated that the first ultra-intelligent machine would be the last thing humans would need to create (Say, 2018).

Scientist Stephen Hawking expressed his concerns with the words, "The rise of strong AI will be either the best or the worst thing ever to happen to humanity. We do not yet know which" (Hern, Stephen Hawking: AI will be 'either best or worst thing' for humanity, 2016).

While many have shared their concerns and speculated on barriers preventing the adoption of Artificial Intelligence, especially in the healthcare sector, there have been no empirical studies examining the reasons for the lack of adoption among various types of Artificial Intelligence (Yu, Chen, & Klein, 2015).

Artificial intelligence, with its many strengths, facilitates human life; however, it remains an area that needs improvement in various aspects. We see that the need for strengthening artificial intelligence in ethical and legal terms continues in today's world.

1.6. ARTIFICIAL INTELLIGENCE IN TÜRKİYE

Türkiye is actively working on raising awareness, increasing usage, and expanding applications of artificial intelligence (AI). The Ministry of Industry and Technology, in collaboration with the Presidency's Digital Transformation Office, has been tasked with developing a national AI strategy. The "National Artificial Intelligence Strategy 2021-2025," prepared in collaboration between the Presidency's Digital Transformation Office and the Ministry of Industry and Technology, with the active participation of all relevant stakeholders, was published in the Official Gazette on 20/08/2021 under the Presidential Decree No. 2021/18 and came into effect. Under the umbrella of TÜBİTAK (Scientific and Technological Research Council of Turkey), the "Artificial Intelligence Institute" has been established. Initially founded at Hacettepe University in 2019, "Artificial Intelligence Engineering" departments have been initiated in universities. Various sectors, including public institutions and the private sector, support and foster the development of artificial intelligence, such as the Ministry of Health's "Artificial Intelligence in Health Competition."

Microsoft President Smith stated: "Artificial intelligence is transforming society and empowering people with significant advancements in areas such as health, agriculture, education, and transportation. As this technology continues to grow, efforts should be made to distribute artificial intelligence ethically, comprehensively, and transparently worldwide." (EY & Microsoft, 2019). Therefore, a thorough evaluation of the strengths and weaknesses of artificial intelligence is required, with the identification of limits and addressing weaknesses to maximize the benefits of this field.

CHAPTER 2

HEALTH CARE SYSTEMS

2.1. MEANING OF HEALTH CARE SYSTEMS

According to the 1946 World Health Organization (WHO) Constitution, health is not merely the absence of disease or disability but a state of complete well-being in physical, mental, and social aspects. Enjoying the highest attainable standard of health, without discrimination based on race, religion, political beliefs, economic or social status, is recognized as a fundamental right for every individual. The Alma-Ata Conference also emphasized health as a fundamental human right and the need to create appropriate conditions for everyone to benefit from essential health services, irrespective of economic or social circumstances. Health is considered the source of life and a basic need for every individual. Without health, other goods and services hold no meaning for an individual. The Universal Declaration of Human Rights highlights the importance of health: "No economic necessity can be a reason for an act that would harm human health" (Alu, 2017). In the Constitution of the Republic of Turkey, health is described as an "indispensable" right and placed under the guarantee of the state.

According to the Law on Socialization of Health Services (1961), activities aimed at eliminating factors harmful to human health, preventing their impact on community health, treating patients, and providing health services for individuals with physical and mental impairments are referred to as health activities. The World Health Organization defines health services as medical care activities that involve the elimination of various factors harmful to human health, the diagnosis and treatment of diseases, and the restoration of physical and mental abilities in case of loss or reduction (Gençoğlu, Türkiye'de İllerin Gelişmişlik Düzeyi Dikkate Alınarak Sağlık Hizmetlerinin Kümeleme Analizi Aracılığıyla Değerlendirilmesi, 2018).

According to the World Health Report prepared by the WHO in 2000, the health system is defined as the sum of all organizations and resources that operate to protect and improve the health of communities. Health systems are characterized as any activity whose fundamental purpose is to protect, improve, or enhance health (Murray & Frenk, 2000).

Murray and Frenk, in their study in 2000, defined health activity as a group of activities that aim to maintain and improve health. Within this context, they emphasized that the health system should encompass resources, decision-makers, and organizations related to the financing, organization, and delivery of health activities (Uğurluoğlu & Çelik, 2005). These definitions regarding the health system suggest that a good health system should not only enhance individuals' health but also protect them from the financial burden of illness and enable them to receive treatment.

The goals of health systems show slight variations in alignment with the policies implemented by countries. However, the concepts of health improvement, effectiveness, efficiency, and equity are universally accepted and embraced objectives of health systems across all countries (Sungur, 2021). In the "Health System Reviews" report published by the OECD in 2008, the goals of health systems were classified under three main headings (OECD, 2008). These objectives are outlined below:

- Improving the health of the community. (Improvement of health status)
- Ensure that the health system meets the expectations of society. (Financial protection of responsiveness and disease-related costs)
- Establishing a structure that ensures fair participation of the society in the financing of the health system. (Fair financing)

The success level of countries' implemented health systems depends on how effectively these goals are achieved. As these objectives are met, the success of countries' health systems increases.

According to the World Health Organization (WHO), a country's health system should be designed to ensure the delivery of high-quality health services that are necessary for everyone. Health services should be effective and cost-effective, protecting individuals benefiting from the services from financial risks. Health systems should possess the capacity to respond to the needs of the entire society, and inclusivity across the entire population should be ensured within the system (Kumbasar & Arslan Kurtuluş, 2015). In this context, in 2012, the United Nations General Assembly adopted a resolution supporting Universal Health Coverage. Additionally, in 2019, the WHO designated the World Health Day theme as "Universal Health Coverage: Everyone, Everywhere." Universal Health Coverage (UHC) is defined as all individuals and communities having access to the health services, they need without suffering financial hardships. In other words, it is a principle aiming for health services to be accessible and affordable. With the application of this principle, no one, metaphorically speaking, will be "left behind," and they will be able to benefit from health services easily. This situation will contribute to the long-term economic development of countries (TURKMSIC, 2022). The WHO recommends that each country develop its own health system, taking into account these factors based on its cultural, social, and political structure. Health, the foundation of everyone's life, also forms the basis of a developed and prosperous society. Therefore, health is an essential indicator of a country's development levels. In almost all countries, health is considered a government obligation and a public service because a healthy society opens the way for the economic development of countries and forms the basis of development.

2.2. ECONOMIC EFFECTS OF HEALTH SYSTEM

Health systems profoundly impact countries' economies in various ways, particularly in terms of welfare levels, sustainable development and human capital. In other words, health systems are deeply related to the economic systems of countries. Access to health services is critically important for people to lead a healthy life and participate in the workforce.

Human capital is defined as the positive values such as knowledge, skills, experience and dynamism possessed by the labor force participating in production and enabling more efficient use of other factors of production (Doğan, 2016). According to Mushkin (1962), Becker (1964), and Grossman (1999), health is one of the most important factors in improving human capital. Renowned economists Romer (1986) and Lucas (1988) have expressed that human capital has positive effects on economic growth. Improvements in health increase labor productivity because healthy individuals enhance their knowledge and skills through education, thereby increasing labor productivity, which has a positive impact on the level of countries' growth and development (Uzay, 2005). The increase in the level of health enhances life expectancy, which has a positive effect on labor supply (Gençoğlu, 2016). Health also influences the labor force's participation rate and the quality (productivity) of the workforce.

Furthermore, the health sector serves as a significant source of employment. Therefore, an increase in employment in this sector will contribute to a reduction in unemployment rates. This situation is expected to have positive effects on economic growth as well.

Life expectancy, which increases due to the increase in the level of health, expresses the possibility of individuals to have a longer life expectancy. Such a situation encourages individuals to save money (WHO, 2006). It has been determined that improvements in life expectancy have a positive effect on economic growth in the long term (Bozkurt, 2010).

Health also has a considerable impact on investments. An individual's or society's improved health level can lead to changes in consumption and investment decisions (WHO, 2006). Improvements in people's health conditions result in a decrease in health-related expenses, such as spending on medication and doctors, within consumption expenditures. This situation allows the portion of the budget not used for health expenses to be converted into savings or investments, thereby transforming consumption expenditures into investments (Gençoğlu, 2016).

Health possesses a strong public good characteristic. An individual's health condition not only affects themselves but also has an impact on the overall health level of society. This condition, by enhancing the quality of life in societies and preventing social exclusion, will have positive effects on sustainable development. As evident from the reports of the United Nations Development Program (UNDP), sustainable development in countries is unlikely to be achieved without a healthy society.

As observed, health holds significant importance at the individually and socially. Health forms the foundation of an advanced and prosperous society. Improved health contributes to growth, and an increase in the level of growth helps reduce the financial burden on global health systems. The quality of health systems and the accessibility of health services also contribute to economic development (Güven, Tevfik, & Ebru, 2020). In the long term, investments in the health sector minimize societal inequality, provide opportunities for advanced technology transfer, and have a reducing effect on the Gini coefficient (Yavuz Tiftikçigil, Önem, Özdökmeci, & Bozaykut Bük, 2022). Investments in health have a highly positive return for the welfare of society. Health systems play a key role in fundamental economic indicators of countries, including economic development, labor productivity, investments, and savings. In other words, they are a significant indicator of the development levels of countries. Therefore, from an economic perspective, health services are one of the world's largest sectors.

2.3. THE CURRENT SITUATION OF HEALTH SYSTEMS

The healthcare sector, with an annual revenue exceeding 12 trillion dollars and approximately 60 million healthcare personnel, stands as one of the world's largest industries (World Economic Forum, 2023). The Organization for Economic Co-operation and Development (OECD) defines the healthcare sector as the fastest-growing sector in the world in terms of economic size (OECD, 2018). United Nations reports also indicate that the role of the healthcare sector in the global economy will continue to increase over time. The World Health Organization emphasizes the importance of a country's health expenditure share being at least 5% of its Gross Domestic Product (GDP), underscoring the significance for developing or less developed countries to adopt this as a target (Daştan & Çetinkaya, 2015).

On the other hand, the magnitude of healthcare expenditures does not necessarily imply the excellence of a country's healthcare system. It is crucial not to confuse these two phenomena. Healthcare expenditures vary among countries with different healthcare systems. However, it is understood that these diverse expenditures are not directly correlated with health indicators, success rates, and efficiency of healthcare systems (Daştan & Çetinkaya, 2015). The United States serves as a prime example of this situation. According to OECD's 2021 data, the U.S. spends 17.8% of its GDP on healthcare, nearly twice the average of OECD countries. Despite high expenditures, the U.S. exhibits the lowest life expectancy at birth, the highest mortality rates due to preventable or treatable diseases, the highest rates of maternal and infant mortality, and the highest suicide rates among high-income countries lacking universal health insurance. Simultaneously, the U.S. has the highest prevalence of people with multiple chronic conditions. The obesity rate among Americans is nearly twice the OECD average. These results indicate that, despite the high spending in the U.S., its citizens experience more health issues compared to OECD countries (Gunja, Gumas, & Williams II, 2023).

In the present day, the healthcare sector, which is one of the world's largest industries, faces certain challenges. According to the results of the "Global Health Service Monitor 2022" survey published by IPSOS in 2022, issues such as access to treatment, waiting times, staff shortages, and bureaucracy are identified as the most significant problems.

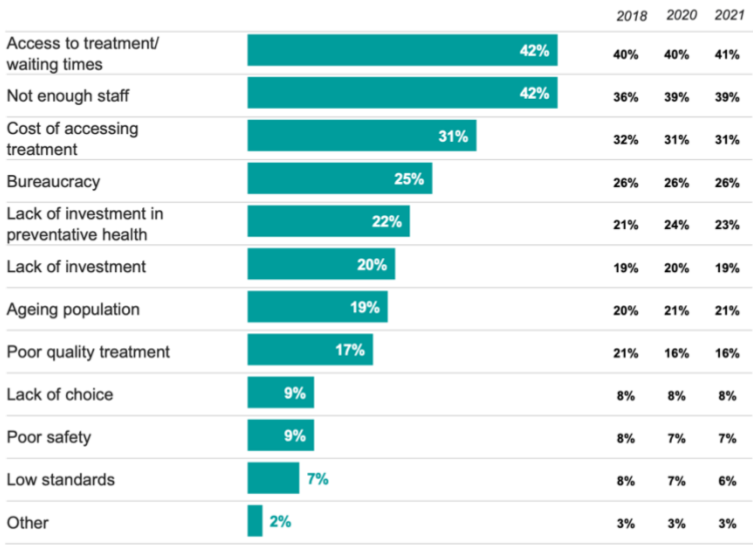


Figure 10:*Global Health Service Monitor 2022" Survey Results*

When looking at the current OECD data, it is observed that Norway is the country most satisfied with the quality of healthcare services among OECD countries in 2020, with a satisfaction rate of 92.5% of its population. Belgium follows as the second most satisfied country with a rate of 92.2%. Estonia has the highest proportion of the population with unmet medical examination needs due to financial, geographic, and waiting time reasons in 2019, with a rate of 15.5%, making it the highest among OECD countries.

Currently, the global healthcare system predominantly operates with a focus on hospitals. However, hospitals are not designed to handle the chronic, complex, and long-term diseases of a large number of people (STM ThinkTech, 2019). The World Health Organization has stated that there should be at least 3 hospital beds per thousand people in a hospital. According to the data of the OECD and the Statistical Office of the European Union (Eurostat), the countries with the highest ratios are South Korea (12.7 hospital beds per thousand people) and Japan (12.6 hospital beds per thousand people). With approximately 6 doctors per thousand people, Greece had the highest doctor density among OECD countries in 2019, and South Korea had the highest face-to-face doctor examination rate.

In the last 20 years before Covid-19, significant developments have occurred in the field of health globally. Thanks to scientific and technological advancements, the quality of life has improved significantly in developed countries. Simultaneously, "Health and Well-being" globally became one of the "Sustainable Development Goals (SDGs)" defined by the United Nations in 2015, planned to be achieved worldwide by 2030 with the participation of 193 countries. However, it is still observed that the developments in the health sector do not fully reflect developing and underdeveloped countries. A large part of the world's population is still deprived of today's healthcare opportunities. Looking at the global health situation, 75% of total deaths are caused by preventable diseases. In low/middle-income countries, this rate is even higher. In other words, 77% of all deaths due to non-communicable diseases occur in low and middle-income countries (WHO, 2022). The main causes of death are attributed to unplanned and rapid urbanization, unhealthy eating habits, sedentary lifestyles, smoking and alcohol use, and an aging population. In today's world, millions of people cannot access healthcare services and cannot be adequately nourished. Unprecedented health problems are faced due in part to global climate change, environmental pollution, and partly poor living conditions.

Between 2000 and 2019, the number of deaths caused by non-communicable diseases (NCDs), or in other words, NCDs, increased by more than a third, rising from 31 million to 41 million. This indicates that almost 3% of every four deaths worldwide are attributed to non-communicable diseases. Cardiovascular diseases, cancer, chronic respiratory diseases, and diabetes are examples of non-communicable diseases that, while not infectious, cause the highest number of deaths. In 2019, 17.9 million people died from cardiovascular diseases, 9.3 million from cancer, 4.1 million from chronic respiratory diseases, and 2 million from diabetes. In summary, non-communicable diseases resulted in the deaths of approximately 33.3 million people in 2019. This situation indicates a 28% increase compared to deaths from non-communicable diseases in 2000 (WHO, 2023).

Preventive, diagnostic, and treatment services for NCDs need further improvement. For instance, despite a significant increase in the diagnosis, treatment, and control rates of hypertension from 2000 to the present, in 2019, nearly half of the global population with hypertension remained undiagnosed, and only about one-fifth of hypertensive patients had effective treatment. Furthermore, in only 20% of countries, there are early detection possibilities for childhood cancers, 38% for colon cancer, 59% for breast cancer, and 62% for cervical cancer at the primary healthcare level (WHO, 2023).

There is a tight causal relationship between non-communicable diseases and poverty. People with already poor socioeconomic status are more likely to engage in harmful habits such as smoking, alcohol consumption, and unhealthy eating. Due to difficulties in accessing healthcare services, they are more prone to illnesses and, consequently, higher premature mortality rates compared to those with higher socioeconomic status. As a result, the increase in non-communicable diseases over time contributes to increasing healthcare expenditures. It poses a significant burden on household incomes that are already at a low level. The exorbitant costs of non-communicable diseases, including prolonged and expensive treatment processes, combined with income loss, lead to millions of people being pushed into poverty every year. This situation hinders efforts to reduce poverty in low-income countries, creating a vicious cycle that impedes national development.

Non-communicable diseases (NCDs) not only pose a significant public health problem but also represent a severe threat to future social and economic development (Sapkota, Baral, Berger, Parhofer, & Rehfuess, 2022). According to the World Health Organization's statistics for the year 2023, it is predicted that by 2030, no region will achieve Sustainable Development Goals related to NCD deaths. If the current trend continues, it is estimated that by 2048, deaths due to non-communicable diseases will constitute 86% of total deaths. Additionally, climate change is expected to increase the number of deaths from conditions such as malnutrition, malaria, diarrhea, and heatstroke between 2030 and 2050 by approximately 250,000.

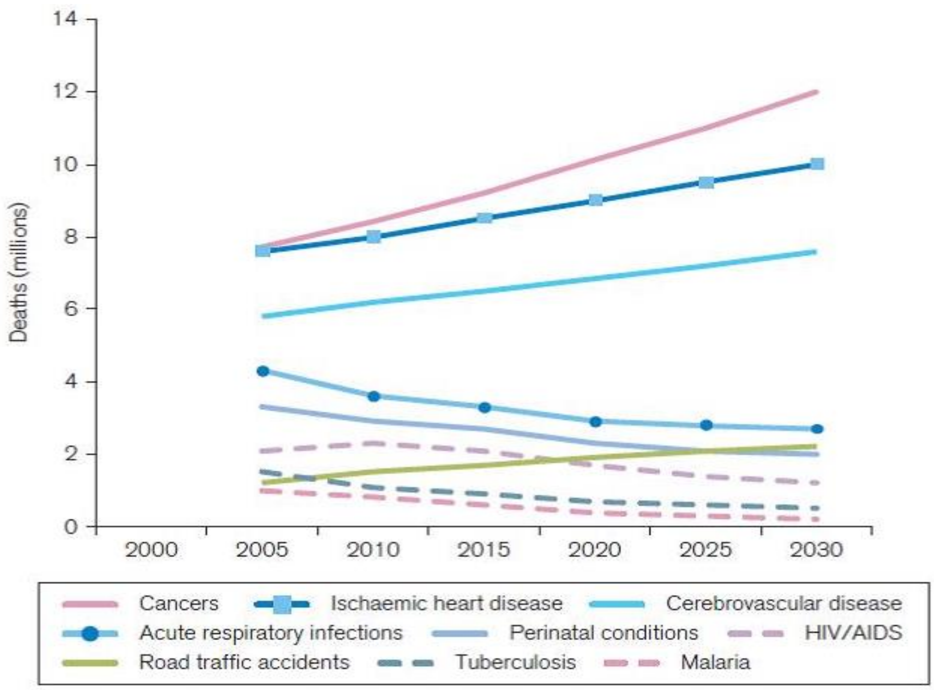


Figure 11:*Global Deaths for Selected Causes, 2004-2030*

Source: *WHO*

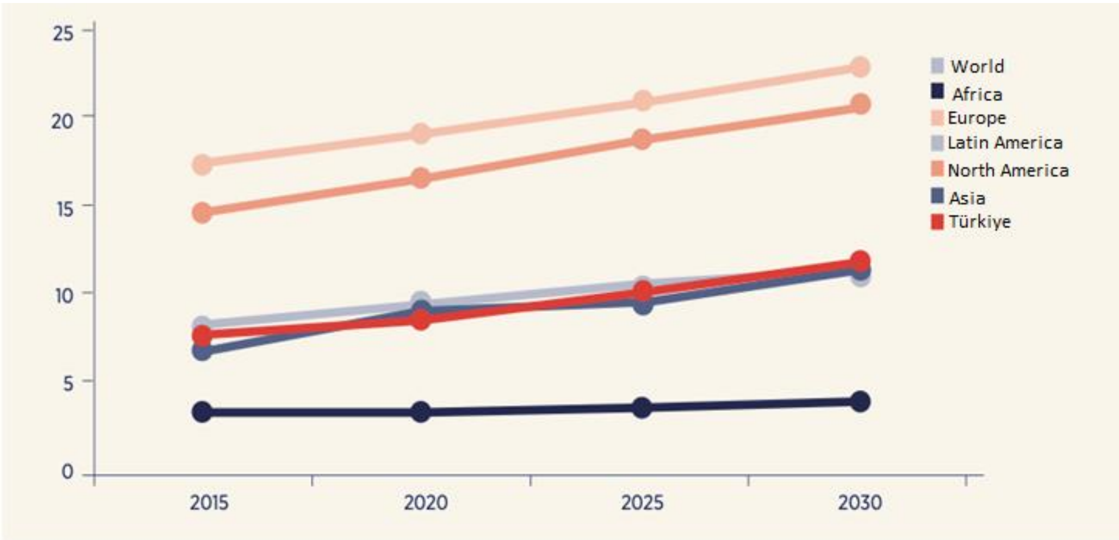
It is evident that non-communicable diseases (NCDs) are one of the most significant threats facing the 21st century. The expenditures on combating NCDs are estimated to reach around 30 trillion US dollars over the next 20 years (WHO, 2016).

In the past century, advancements in science, technology, education, economy, food, housing, water, and sanitation have led to progress in health globally. Consequently, mortality rates due to infectious diseases have decreased, and life expectancy at birth has increased. In other words, improvements in health technology and the quality of healthcare services have contributed to the overall increase in life expectancy worldwide.

There are also striking changes in the demographic structure of the population today. In 1950, the average life expectancy was only 46.5 years, whereas a baby born today is expected to live almost 25 years longer than those born in 1950. According to the World Social Report published by the United Nations on January 12, 2023, the global population aged 65 and over, which was 761 million in 2021, is projected to more than double to 1.6 billion by 2050, while the total world population will reach 9.7 billion (UNDESA, 2023).

The UN report notes that Europe and North America currently have the highest proportion of elderly populations globally. However, over the next 30 years, North Africa, Western Asia, and sub-Saharan Africa are expected to experience the fastest growth in the elderly population. In summary, the average life expectancy is increasing worldwide.

This trend is particularly evident in low- and middle-income countries, where a reduction in mortality rates at young ages and deaths from infectious diseases has occurred. Most elderly individuals now reside in low- and middle-income countries, and this distribution is expected to continue increasing (Briggs, et al., 2020).



Kaynak: United Nations, Department of Economic and Social Affairs, Population Division

Figure 12:*+ 65 Age People in the Total Population*

At the present time societies, a population is considered "elderly" when the share of the population aged 65 and over exceeds 8-10% of the total population (Erol, 2012). As can be understood from the above graph, this proportion is rapidly increasing worldwide.

Despite the rapid aging of populations worldwide, it is not possible to assert that increased life expectancy equates to a prolonged period of healthy life. Presently, there is insufficient data to support the notion that elderly individuals are healthier than their peers of the same age (Crimmins & Beltrán-Sánchez, 2011). In other words, the additional years gained in life expectancy often unfold within unfavorable health conditions. In essence, the extension of human life does not necessarily imply a healthy aging process.

The growth and demographic aging of the global population bring about increased costs in healthcare. With longer lifespans, the probability of developing chronic diseases also rises. In the future, the increasing share of the elderly population within societies, coupled with diseases associated with aging and the corresponding treatment expenses, will contribute to a general increase in expenditures. The disease surge will lead to a significant rise in demand for healthcare services. Consequently, this situation will augment the burden on healthcare systems, despite the increase in per capita national incomes in countries. The aging of the population has substantial implications for labor markets, social insurance systems, and public finances due to the substantial share of health expenditures in state budgets. As a result of the growing proportion of the elderly population in the total population, the ratio of health expenditures to GDP will continue to rise over time.

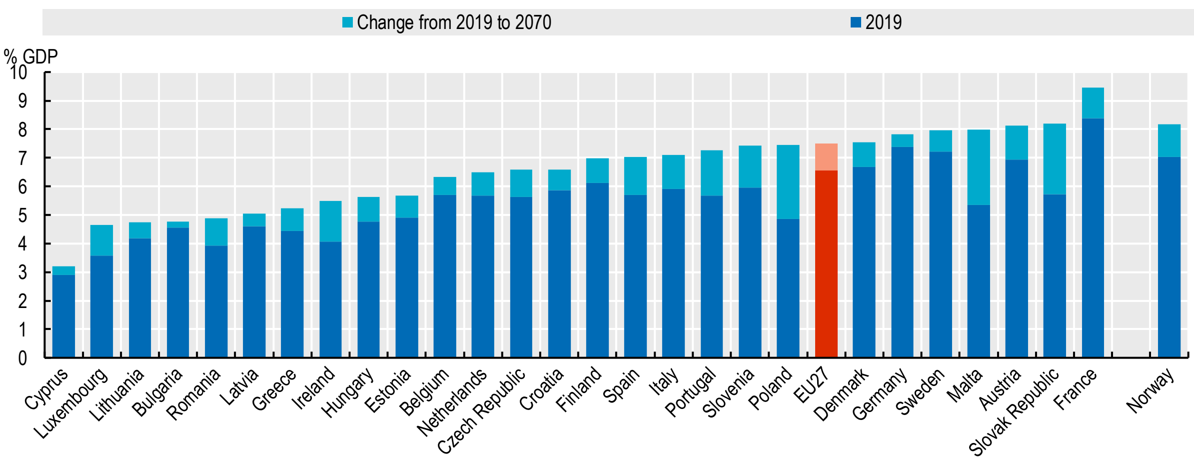


Figure 13:*Public Spending on Health Care as a Percentage of GDP, 2019-70 – Ageing Working Group Reference Scenario*

Source: *OECD (https://www.oecd-ilibrary.org/sites/5b352bdf-en/index.html?itemId=/content/component/5b352bdf-en#figure-d1e22933-de5f2aed19)*

As observed, the ratio of healthcare expenditures to GDP has been on the rise over the years. However, the sole reason behind this increase is not only the growing healthcare costs due to an aging population. This surge is partly attributed to the escalating prices in the healthcare sector, increased demand for services, and advancements in medical Technologies (Gunja, Gumas, & Williams II, 2023). The global healthcare sector, in general, is under financial pressure (STM ThinkTech, 2019).

Healthcare expenditures in all countries are increasing at a rate higher than the countries' economic growth rates. Therefore, the share of healthcare expenditures in the overall economy has been consistently increasing since the 1980s. In most OECD countries, health expenditures, which are mostly composed of medicines, medical devices and salaries of health personnel, are mostly financed from public resources.Hence, the financial sustainability of the rising expenditure trend poses a significant concern (Lorenzoni, Marino, Morgan, & James, 2019).

In other words, the cost of healthcare services is on an unsustainable upward trajectory. According to the World Health Organization's report titled "Public Spending on Health: A Closer Look at Global Trends," published in 2016, the share of health in the public budget decreased by 2% in low-income countries in 2016. The rate of increase in the share of health in the national budget in middle and high-income countries has followed a horizontal trend since 2012 (STM ThinkTech, 2019). In low and middle-income countries, the increase in health expenditures is driven by the increase in public health expenditures. However, due to cost pressure, the share allocated to health in the public budget is progressively diminishing. This situation places countries at the risk of restricting access to healthcare services in the future due to the aforementioned cost pressure.

As evident, concerns exist today regarding the long-term sustainability of existing healthcare services. As obesity, chronic diseases, an aging population, and health inequalities continue to rise, the share of healthcare and care services from the GDP will continue to increase worldwide. The World Health Organization predicts that by 2030, we will face a shortage of 30 million jobs in the global healthcare workforce. Therefore, the importance and necessity of transitioning to digitization, automation, and artificial intelligence in healthcare systems are increasingly recognized.

2.4. DIGITALIZATION ACTIVITIES IN THE HEALTH SYSTEM

The Industrial Revolution, initiated in the 18th century with the introduction of water and steam-powered machinery, brought about a transformative period of innovations in various aspects of our lives, including health (Akalın & Veranyurt, Sağlıkta Dijitalleşme ve Yapay Zeka, 2020). The process that led us to the widely discussed Industry 5.0 began in the 1760s in England with the establishment of mechanical production systems utilizing water and steam power.

In the subsequent phase, known as Industry 2.0, electricity was introduced into production, enabling the transition to mass production. Starting from the 1970s, the widespread use of computers marked the era known as Industry 3.0, characterized by the extensive use of information technologies and electricity in production (Kagermann, Wahlster, & Helbig, 2013, pp. 13-14). Industry 4.0, the present-day phase, signifies a rapid digital transformation in both industrial and societal contexts, incorporating technologies such as smart factories, cyber-physical systems, the Internet of Things, autonomous robots, artificial intelligence, cloud computing, big data, augmented reality, and 3D printing (ST Endüstri Dergileri, 2018).

In January 2016, the Japanese government introduced the concept of Industry 5.0 in the Council for Science, Technology, and Innovation. Recently integrated into our lives and alternatively termed Society 5.0, this concept is characterized as the era of unmanned technology (Celep, 2020).

Advancements in technology have increased individuals' access to technological tools and applications, enabling them to perform activities in the digital realm. Developments in science and technology have significantly impacted human life, particularly in production, industry, and the service sectors. These technological advancements have also led to transformations in the healthcare sector, one of the largest sectors in the global economy.

The increasing aging of the world population, resulting in a rise in demand and costs for healthcare systems, the escalation of deaths due to chronic diseases, workforce shortages, global problems such as pandemics and infectious diseases affecting many countries, and cost pressures are among the challenges that the global healthcare sector is striving to address. In the face of these issues, the importance of technological solutions for the healthcare sector has been growing steadily. For the healthcare system to function optimally, it is imperative to eliminate or minimize existing problems (Akalın & Veranyurt, Sağlıkta Dijitalleşme ve Yapay Zeka, 2020). The need to address such issues has spurred digital transformation in healthcare.

Thomas Edison once said, "The future doctors will no longer treat the human frame with drugs, but rather will cure and prevent disease with nutrition and lifestyle." With this statement, Edison alluded to the transformation that would occur in the healthcare system. The transformation process in healthcare has evolved parallel to the advancements witnessed during the Industrial Revolution. In this context, the transformation in healthcare has been defined by Chen and colleagues in a structure resembling the Industrial Revolution, with four distinct periods (Chen, Loh, Kuo, & Tam, 2019).

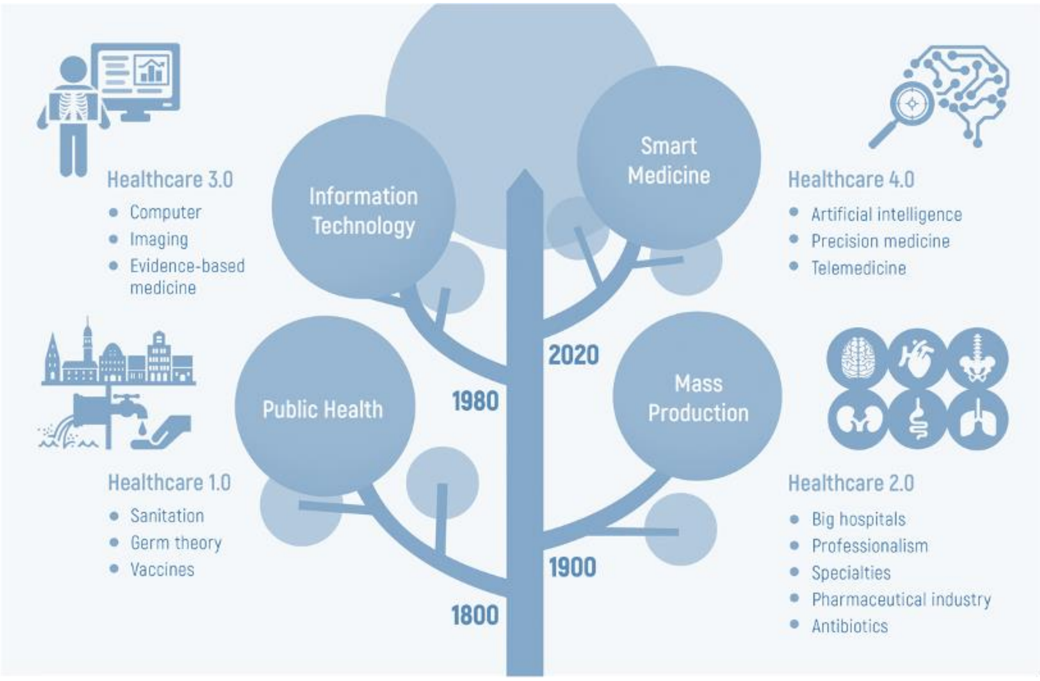


Figure 14*:Four Transformation Sessions of Health System*

2.4.1. <u>Health 1.0</u>

The period resulting from the health implications of developments during Industry 1.0, referred to as Health 1.0, encompasses the late 19th century to the mid-20th century (Koştı, Burmaoğlu, & Kıdak, 2021). During this era, the focus was primarily on public health. Physical health services, such as controlling vital signs and facilitating natural childbirth, were provided (Ahsan & Siddique, 2022).

In the early stages of this period, health problems were believed to stem from magic or witchcraft, and diseases were thought to occur as a result of good or evil spirits entering a person's body. It was believed that diseases were cured by shamans, priest-healers, or magicians who communicated with supernatural elements (Koştı, Burmaoğlu, & Kıdak, 2021). After the industrial revolution in the late 19th century, therapeutic experimental methods began to be used in health. Approaches in medicine have become more evidence-based and rational.

During this period, the British Government provided evidence that endemic diseases were caused by contaminated drinking water, leading to the introduction of water pipes delivering drinking water to homes. This prevented the occurrence and spread of infectious diseases (Chen, Loh, Kuo, & Tam, 2019). Additionally, it was discovered that contagious diseases causing epidemics were microbe-related (Burns & Grove, 2007). The discovery of treatment methods such as antibiotics and vaccines were also a significant development in the field of health during this period (Koştı, Burmaoğlu, & Kıdak, 2021). In summary, substantial progress was made in public health during this period.

2.4.2. Health 2.0

With the advent of the Second Industrial Revolution, this period saw the initiation of mass production in the automobile industry. As a result of the developments in Industry 2.0, significant advancements occurred in the health industry. During this period, major pharmaceutical companies were established, leading to the introduction of numerous antibiotics into the market (Chen, Loh, Kuo, & Tam, 2019). Hospitals expanded their capacities, addressing the emerging shortage of doctors by training qualified specialists with medical education. Both basic science education and clinical training became equally crucial in medical education. Trained professionals with expertise in health began to play a role in the diagnosis and treatment processes of individual patients, utilizing advanced technological tools and equipment (Koştı, Burmaoğlu, & Kıdak, 2021). Consequently, patients received services from a greater number of professionals (Akalın & Veranyurt, Sağlıkta Dijitalleşme ve Yapay Zeka, 2020).

2.4.3. Health 3.0

The era known as Industry 3.0, also referred to as the Information Technology era, commenced as a result of rapid developments in electronic and information communication technologies following the Second World War. In the 1980s, computers became smaller and faster, the internet emerged, and communication and information technologies advanced. The reflections of these developments in the health sector manifested in imaging and electronic health record systems.

Computer-based patient record systems were first introduced in hospitals in the 1960s. From the 1980s onwards, integrated patient record and digital imaging systems, encompassing clinical information systems, began to be utilized. With the advancement of technology in the 2000s, electronic health systems came into use (Koştı, Burmaoğlu, & Kıdak, 2021).

The rapid progress of computer technologies facilitated the improvement of tomography images, enabling doctors to examine injuries in more detail and identify diseases earlier (Chen, Loh, Kuo, & Tam, 2019). In other words, diseases began to be diagnosed earlier by physicians.

In addition, access to information has become more accessible thanks to the internet. Thus, doctors and health researchers have gained faster access to medical literature. This situation has accelerated the development of evidence-based medicine (Chen, Loh, Kuo, & Tam, 2019).

2.4.4. Health 4.0

Industry 4.0 is a concept that describes a rapid digital transformation in both industrial and societal contexts, encompassing technologies such as cyber-physical systems, the Internet of Things (IoT), autonomous robots, artificial intelligence, cloud computing, big data, augmented reality, and 3D printing. Through this digital transformation, new concepts such as artificial intelligence, big data, cloud technologies, the Internet of Things (IoT), augmented reality, and 5G technologies have also started to be used in health. Health 4.0 emphasizes virtualization, personalization, and the overall improvement of the health industry through technology for patients, health professionals, and other stakeholders (Thuemmler & Bai, 2017).

During this process, various innovations, such as surgical care robots, wearable devices, smartphone applications, 3D printers, smart tablets (pills), telemedicine, and more, have become part of our lives (Battal, 2018).

With the Health 4.0 process, innovations have emerged to increase human lifespan, facilitate early diagnosis, enable personalized treatment methods, and make remote diagnosis and treatment possible (Vogel, 2017).

In the current process, a shift has begun in the healthcare sector towards a value-based system that measures results rather than focusing on fee-based services, leading to proactive preventive measures indirectly reducing costs and improving service quality (Bause, Esfahani, Forbes, & Schaefer, 2019). Health 4.0, operating with real-time data from networked electronic health record systems, artificial intelligence, invisible user interfaces, and wearable devices, is paving the way for significant developments in the healthcare sector (Koştı, Burmaoğlu, & Kıdak, 2021). Today, digital transformation in healthcare continues, and artificial intelligence in the above-mentioned digital solutions in healthcare services is becoming increasingly important.

2.5. USE OF ARTIFICIAL INTELLIGENCE IN THE HEALTHCARE SYSTEM

Artificial intelligence in health is "the sum of a large number of technologies that enable machines to feel, understand, act and learn, and can undertake administrative and clinical health services" (Collier & Fu, 2020). AI has a broad range of applications in the field of health. The necessity of utilizing this technology is increasing every day for addressing various problems, enhancing quality, ensuring sustainability, increasing efficiency, and providing effectiveness in healthcare (Jiang, et al., 2017). In the healthcare services sector, AI technologies benefit patients and healthcare providers in predicting, diagnosing, and treating diseases (Li Yan, 2020).

The goal of artificial intelligence technology in the health sector is to assist healthcare professionals in making accurate clinical decisions, provide more efficient personalized services to patients, reduce existing costs in the healthcare system overall, make healthcare accessible to everyone, and enhance the efficiency of the healthcare system by reducing medical errors (Jayaraman, Forkan, Morshed, Haghighi, & Kang, 2020).

The potential of artificial intelligence in healthcare is immense, making it a focus not only for governments but also for technology organizations (STM ThinkTech, 2019). However, despite the rapid adoption of AI technology in healthcare by the health industry and stakeholders, the number of studies in the literature considering the effects of AI in healthcare is quite limited (Ali, et al., 2023).

Artificial intelligence is used for administrative and clinical purposes in health (STM ThinkTech, 2019). In this context, the areas of use of artificial intelligence in the field of health are given in the table below:

Table 1: Usage Areas of AI

Administrative Use of Artificial Intelligence	Clinical Use of Artificial Intelligence
General Health Management	Public Health Management
Documentation Management	Early Diagnosis and Emergency Response
Cost and Quality Management	Evaluation of Radiology Images
Effective Use of the Capacity of the Health Institution	Tracking Test Results
Remote Preventive and Complementary Health Services	Treatment and Artificial Intelligence Supported Robotic Surgery
Eliminating Irregularities in Health System	Drug Development

2.6.HISTORY OF THE USE OF ARTIFICIAL INTELLIGENCE IN THE HEALTHCARE SYSTEM

While the term artificial intelligence (AI) entered our lives in the 1950s, the utilization and development of AI technology in the healthcare domain trace back to the 1970s. Since this historical period, various AI-based advancements have occurred. For instance, in the 1970s, Stanford University developed an expert system named MYCIN to prevent unnecessary and excessive antibiotic usage. MYCIN was utilized for the diagnosis and treatment of infectious diseases, particularly meningitis, and for prescribing the correct antibiotic for its treatment. It was designed to provide recommendations to expert physicians for patient management and to reduce the excessive use of antibiotics by patients. The system comprised a set of rules between 400 and 700 (Kaul, Enslin, & Gross, 2020).

In 1973, with the establishment of SUMEX-AIM Computing Resource at Stanford University, the use of artificial intelligence in medicine was further encouraged (Patel, et al., 2009). CASNET, developed at Rutgers University, was among the first applications of AI technology in medicine, specifically employed for the diagnosis of glaucoma eye disease (Kulikowski & Weiss, 1982). During this period, scientists developed INTERNIST-I, a broad-based computer-aided diagnostic tool utilizing a robust ranking algorithm to reach diagnoses (Miller, Pople, & Myers, 1982).

In 1986, a decision support system called DXplain, developed by the University of Massachusetts, became operational (Kaul, Enslin, & Gross, 2020). DXplain, which produced diagnoses for 500 diseases using the symptoms entered when it was first released, can now provide definitions of more than 2600 different diseases (mghlcs, 2017). Additionally, it serves the purpose of an e-book for medical education (Kaul, Enslin, & Gross, 2020).

PUMA, developed by Victor Scheinman in 1985 and Kwoh in 1985, was the first robot surgeon referred to as a robot and was used on a human patient for urological surgeries (Samadi, 2018).

By the 1990s, the use of artificial intelligence technologies in medicine became more widespread. The advancements in computers and increased data storage capacities led to significant developments in the healthcare domain. Progress was observed in medical image processing and radiology applications, with artificial intelligence methods being particularly employed in MRIs. Additionally, the Pathologist Interpretive Reporting System achieved approximately 95% diagnostic accuracy in preparing pathology reports (Ulve, 2023).

In the late 1990s, increasing interest in machine learning, especially in the medical world, paved the way for the era of artificial intelligence in health (Kaul, Enslin, & Gross, 2020). On this basis, a study was conducted in 1991 in the emergency department of a hospital in San Diego, involving 331 patients complaining of chest pain in order to measure the effectiveness of artificial intelligence at the point of diagnosis. At the end of this study, it was proved that an artificial intelligence-based program outperformed doctors in diagnosing heart attack patients correctly (Waldgolz, 1991).

In 2000, the Da Vinci robot, which was approved in the United States and started widely adopted for surgeries, is currently utilized in over 800 operating rooms across 66 countries worldwide. According to official figures provided by the company, more than one million surgeries have been performed globally with over 6,000 Da Vinci robots (STM ThinkTech, 2019).

Another project that benefited from artificial intelligence technology is the Human Genome Project. Completed in 2003, this international scientific research initiative aimed to identify and map all genes of the human genome, both physically and functionally. Involving numerous countries and institutions, the project sought to characterize all genes and genetic variations in human DNA, providing valuable insights into human health and diseases. The project resulted in producing a genomic sequence that represents over 90% of the human genome (National Human Genome Research Institute (NHGRI), 2022).

In 2007, IBM introduced Watson, a leading artificial intelligence system. Based on DeepQA technology, Watson achieved significant success by defeating champions in the trivia game show Jeopardy! Thus, it has achieved extraordinary success against human intelligence (Uçar, 2018). IBM Watson is actively involved in significant initiatives in the healthcare sector, including drug research, genetic analyses, disease diagnostics, development of treatments for oncological diseases, and determination of personalized treatment methods (STM ThinkTech, 2019). According to the report by MarketsandMarkets, IBM, along with Google and Microsoft, holds the largest share in artificial intelligence in the healthcare market and is expected to maintain this position until 2025 (Marketsandmarkets, 2018).

Apple's virtual assistant Siri, Amazon's virtual assistant Alexa, Pharmabot and Mandy (these two were developed to help pediatric patients and their parents with medication education) have started to serve in the health field as chatbots (Kaul, Enslin, & Gross, 2020).

In 2017, Arterys received approval from the Food and Drug Administration (FDA) for a product that analyzes heart MRIs in seconds (Imaging Technology News, 2017).. Using artificial intelligence, Google DeepMind predicted the three-dimensional structure of a protein from its amino acid sequence, addressing one of the major challenges in biology (Ulve, 2023). Google's DeepMind Health continues to collaborate with clinicians, researchers, and patients to address real-world health issues. As of October 19, 2023, the U.S. Food and Drug Administration (FDA) has approved the use of 692 artificial intelligence or machine learning-enabled devices (The Food and Drug Administration (FDA), 2023)Investments in artificial intelligence research for medical purposes by healthcare institutions and the private sector are rapidly continuing today.

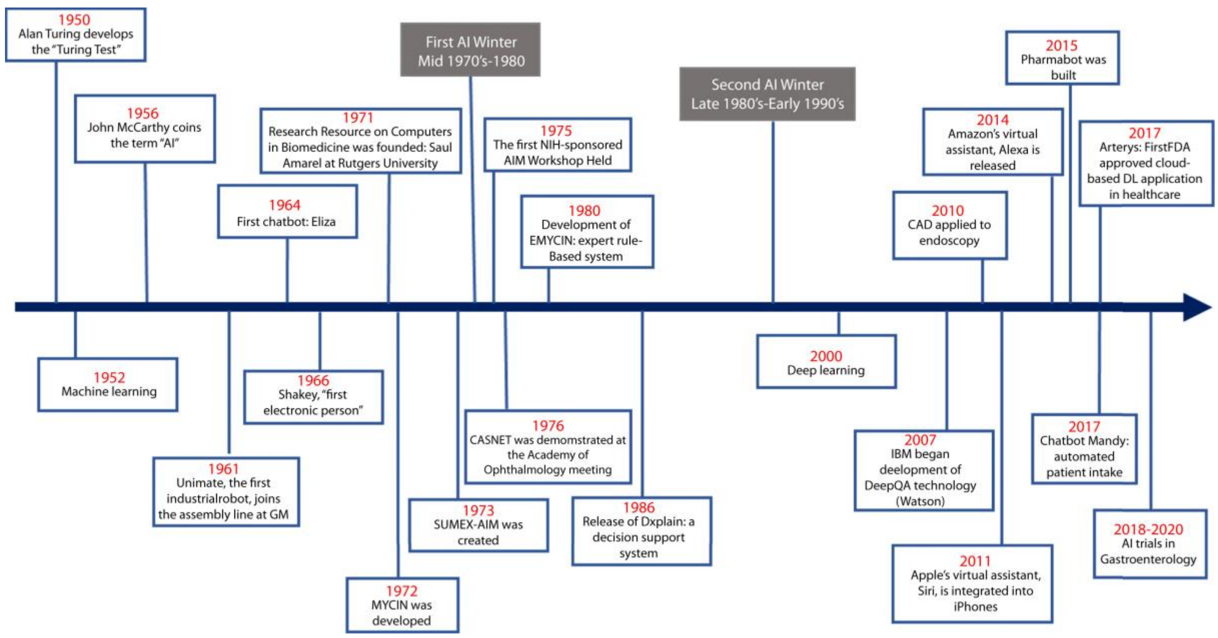


Figure 15:*Historical Background of AI in Healthcare System*

Source: *Kaul et al.; History of Artificial İntelligence in Medicine*

2.7. THE FUTURE OF USING ARTIFICIAL INTELLIGENCE IN THE HEALTHCARE SYSTEM

Artificial intelligence technology is rapidly transforming and dominating the healthcare sector in various areas, such as diagnosis, treatment, patient monitoring, drug discovery, patient management, and imaging. Ongoing developments in this field significantly benefit healthcare providers and patients. The advanced algorithms of artificial intelligence play a crucial role in making the delivery of healthcare services more effective and personalized.

According to a report published by the World Economic Forum in 2020, artificial intelligence will transform the healthcare sector in three fundamental ways by 2030. Firstly, artificial intelligence is currently collecting data related to conditions defined by the World Health Organization as "social determinants of health," which impact our lives. This situation will further develop by 2030, enabling healthcare systems to predict when an individual is at risk of developing a chronic disease and suggest preventive measures before the condition worsens. Even today, this approach has led to a reduction in the rates of diseases such as diabetes, congestive heart failure, and Chronic Obstructive Pulmonary Disease (COPD).

The second transformation will significantly impact the current understanding of hospitals. By 2030, hospitals will evolve into "Health Networks" that provide services at the patient's home or the nearest accessible location rather than expansive buildings covering various illnesses. There will be a shift from a hospital-centric to a patient-centric healthcare approach, emphasizing personalized treatments (STM ThinkTech, 2019). In essence, a process is envisioned where the patient's interaction with a physical hospital is minimal (Akalın & Veranyurt, Sağlıkta Dijitalleşme ve Yapay Zeka, 2020).

Another transformation will occur in AI-powered predictive healthcare networks by 2030. The evolving healthcare networks will focus on reducing wait times, improving staff workflows, and handling the increasing administrative burden. Additionally, it is anticipated that new types of work, such as AI-supported healthcare technicians, will emerge (McKinsey&Company, 2020).

In addition to areas where AI solutions, such as radiology and oncology, are already being employed, the emergence of AI solutions for health issues like mental health and trauma is expected. AI is predicted to contribute to developing treatment methods for previously untreatable diseases. Furthermore, there is a growing focus on chronic diseases like Alzheimer's and kidney diseases, and in the near future, AI-based applications are likely to become more prevalent in the diagnosis and diagnostic processes of these diseases (Akalın & Veranyurt, Sağlıkta Dijitalleşme ve Yapay Zeka, 2020).

According to the predictions outlined in the "Artificial Intelligence in Healthcare Market" report published by the research firm MarketsandMarkets, the market size of artificial intelligence solutions for the healthcare sector is expected to reach $36.1 billion by 2025 (Marketsandmarkets, 2018). It is estimated that within a decade, it will generate revenue exceeding $100 billion and have a market value of over $3 trillion (Ahsan & Siddique, 2022).

Artificial intelligence holds the potential for significant improvements in patient care and future healthcare cost reduction. Bill Gates' statement in 1996, "We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten. Do not let yourself be lulled into inaction," can be applied to the use of AI technology in the healthcare sector. The transformative potential of artificial intelligence in healthcare in the future is likely to be much greater than what we envision today. Therefore, preparation is crucial to harness the transformative potential of AI in the healthcare sector. This transformation comes with various advantages and disadvantages.

2.8. Advantages of Using Artificial Intelligence in the Healthcare System

It is stated that thanks to artificial intelligence applications in the field of health, the work done is redefined, quality and efficiency are increased, costs are reduced and human/system-related errors are minimized (Akalın & Veranyurt, Sağlıkta Dijitalleşme ve Yapay Zeka, 2020). In this context, the advantages of using artificial intelligence in health systems can be expressed as follows:

- Plays an important role in both the calculation and minimization of health costs,
- Contributes to the reduction of workload,
- Reduces the risk of errors by increasing efficiency, (e.g.: Faster and more reliable analysis and reporting of images).
- Saves time,
- Unnecessary treatments are prevented,
- Enables diseases to be diagnosed before they become critical,
- Developments in information technologies increase the health literacy rates of individuals by enabling both health professionals to improve themselves and to follow the studies carried out worldwide,
- It can assist the health sector by detecting fraud allegations. For example: Health insurance fraud is a serious problem in the insurance industry. According to the Federal Bureau of Investigation (FBI), insurance fraud causes an annual loss of $80 billion in the US (*A systematic literature review of artificial intelligence in the healthcare sector: Benefits, challenges, methodologies, and functionalities).* This ensures that damage is prevented.

2.9. Disadvantages of Using Artificial Intelligence in the Healthcare System

While there are advantages of artificial intelligence applications in the provision and management of health services, there are also concerns and disadvantages related to the subject. These include:

- If good training is not performed, unreliable results may be obtained. At this point, the data set used and the samples it contains are very important. In addition, the personnel should be trained correctly for the use of the devices.

- Adequate results may not be obtained in the diagnosis phase by using only images. At this point, especially the support of physicians can be obtained.

- It may pose a risk in terms of responsibility and ethics.

- Maintenance costs of the devices are high.

- There are ethical concerns regarding data security.

- During the transition to the technological process, the workload of users who will use both the new system and the old system will increase. Therefore, transitions should be planned very well and realized as soon as possible.

- There are also concerns that the use of artificial intelligence in healthcare will increase inequality, contrary to the rhetoric that it will reduce inequality. The development, implementation and maintenance of artificial intelligence applications often rely on advanced infrastructures and high-cost technological equipment. While this allows health facilities in developed countries and urban areas to access more AI-based services, health systems in rural and underdeveloped areas may not be able to take advantage of these benefits. This may increase inequality in access to health services.

CHAPTER 3

AREAS OF USE OF ARTIFICIAL INTELLIGENCE IN HEALTH SYSTEM

In health, artificial intelligence technology is used for administrative and clinical purposes. In this section, artificial intelligence applications are analyzed within the framework of these two purposes.

3.1. AREAS OF USE OF ARTIFICIAL INTELLIGENCE FOR ADMINISTRATIVE PURPOSES

3.1.1. General Health Management

In healthcare services, the primary goal of professionals is to improve the patient's condition. The initial step begins with the patient's arrival at the hospital. Success in the process from the first step onwards is crucial. Therefore, technological improvements at each step of this process are very important.

There is a need for AI-based solutions for the numerous and complex administrative activities in the healthcare domain. While the use of AI in administrative areas may not be as revolutionary as its use in clinical settings, it is crucial in terms of the potential to enhance efficiency. In other words, the improvements provided by AI technology are also essential in administrative health services.

Costs associated with administrative activities in healthcare services increase the total cost of healthcare services by billions of dollars annually. This cost tends to rise each year to higher levels. For instance, a report published by the National Academy of Medicine stated that the United States spends 248 billion dollars on general health management related to billing and insurance (Medicine, Yong, Saunders, & Olsen, 2010). Most of these costs arise from fraud, waste, and unnecessary bureaucracy. AI tools will reduce costs, automate data entry, eliminate situations caused by human error, and accelerate administrative operations in healthcare by automatically processing electronic health records (EHR) (Patient Centered Outcomes Research Institute (PCORI), 2023).

Failures in the coordination of general health management can lead to jeopardizing patient safety, unsuccessful clinical outcomes, unnecessary hospital admissions, preventable complications due to human error, poorly managed transitions of patients from one care setting to another, and higher costs. In a study conducted in the United States in 2018, 14% of adults discharged from hospitals were readmitted within 30 days. This results in an annual cost of potentially preventable readmissions estimated at 15 billion dollars (Beauvais, Whitaker, Kim, & Anderson, 2022).

For the healthcare system to function smoothly, all processes are interconnected. Any disruption in the process can result in fatal consequences, risking human lives. Integrating artificial intelligence into ambulance services is crucial for timely emergency medical care and preventing cost increases. Ambulance services, an integral part of emergency medical care, can significantly benefit from AI-focused solutions. Failure to provide emergency care services accurately and on time can lead to fatal and financial consequences. For instance, a study conducted over 12 months in the emergency department of a 450-bed state hospital in Pennsylvania revealed that due to insufficient bed capacity in the emergency department, ambulance diversions, and patients eloping from the emergency department, the hospital incurred a total loss of 3 million USD in a year (Falvo, Grove, Stachura, & Zirkin, 2007).

Beyond the financial aspect, some effects pose risks to human life. The mortality rate is significantly higher for individuals experiencing a heart attack outside the hospital. If cardiopulmonary resuscitation can be administered within 3-5 minutes from the cessation of the heart, the death rate can be reduced. However, for every minute that passes in this process, the patient's chance of survival decreases by 10%. Therefore, the ability of call center operators to quickly send an ambulance to the correct location and guide the relatives accurately over the phone is crucial. However, data indicate that at least 25% of out-of-hospital cardiac arrests go unnoticed (Assuring Autonomy International Programme, 2023). According to a news report by BBC on January 13, 2023, a patient lost their life after waiting for an ambulance for 45 minutes (McCubbin & Triggle, 2023).

In Denmark, stroke-related deaths are among the top ten causes of mortality. It is crucial for patients to reach the hospital quickly from the onset of a stroke. In Denmark, to access initial hospital treatment, patients need to be referred to the hospital by a general practitioner or through the medical assistance hotline of Emergency Medical Services (EMS). According to the results of the study, stroke recognition results using artificial intelligence technology increased the recovery rates of women and young patients (Scholz, et al., 2022).

In the United Kingdom, an AI-based traffic light management system is being used to help emergency teams get to patients faster. An algorithm named Life First Emergency Traffic Control (LIFE) has been developed, allowing healthcare personnel to use real-time data on traffic density. This results in time and cost savings and reduces mortality rates.

In summary, artificial intelligence technology is being used to standardize ambulance response times, thereby preventing delays and deaths. AI-based ambulance dispatch systems consider factors such as the severity of the illness, the availability of an ambulance, and traffic conditions to promptly dispatch the nearest and available ambulance to the patient's location. This contributes significantly to reducing response times, improving diagnosis and treatment, optimizing resource management, and eliminating human errors for healthcare personnel (Jazini, 2023).

In a study conducted in a Taiwanese hospital in 2011, artificial intelligence technology was employed to determine the complaints, severity of symptoms, and medical conditions of patients presenting to emergency services for triage purposes. The findings revealed triage types focusing on high-cost and rare diseases or severe injuries. It was understood that not only the overtime duration in emergencies but also the classification of patients' illnesses is a critical factor in controlling the medical expenses of emergency patients (Lin, Wu, Zheng, & Chen, 2011).

Furthermore, in response to the increasing number of patients in emergency services and the need to predict the resulting intensity, an application calculating the time-dependent emergency service intensity using the Long Short-Term Memory (LSTM) deep learning model has been implemented (Kadri, Baraoui, & Nouaouri, 2019). This application has facilitated the calculation of daily patient numbers for the upcoming period, contributing to the effective use of the limited number of hospital beds (Akalın & Veranyurt, Sağlıkta Dijitalleşme ve Yapay Zeka, 2020).

Next-generation technology enabling access to current patient information with just a few touches on the screen is now reducing mortality rates in emergencies and opening the way for rapid care management.

Activities related to general health management not only incur high costs but also require hospital staff to divert their attention from their primary duties. In their study, Türkmen and Uslu found that nurses spent more time on indirect care practices such as obtaining medication materials, answering the phone, writing prescriptions, and controlling unit entrances and exits rather than direct patient care. They found that nurses spent approximately 1/3 or even more than half of their working hours on indirect care practices (Türkmen, Türkmen, & & Uslu, 2011). In a study conducted in the United States, it was also determined that the average working time of a U.S. nurse was largely dedicated to regulatory and administrative activities (Berg, 2018).

According to a recent survey with the participation of more than 1,600 nurses, it has been concluded that hospital nurses spend a quarter of their 12-hour shifts away from patients' bedsides dealing with legal requirements, unnecessary paperwork, and other indirect care to complete non-direct patient care tasks.

Considering that the care needs of patients, such as monitoring vital signs, respiration, hygiene, nutrition, excretion, treatment practices, and education, are very intense for 24 hours, it is observed that functions other than direct care negatively affect patient care (Türkmen, Türkmen, & & Uslu, 2011). It is thought that these problems can be eliminated by employing virtual nurses instead of real nurses in time-consuming administrative work. While virtual nurses help to reduce unnecessary hospital visits, they can perform many tasks from communicating with patients to providing the best and most effective care instead of real nurses.

The world's first virtual care assistant is Care Angel. This virtual care assistant is a voice-activated assistant that uses real-time clinical and non-clinical data to make informed decisions and reduce unnecessary hospital visits. It plays a role in ensuring patients' care plans and medication adherence (Lee & Yoon, 2021).

Artificial intelligence-based chatbots are also utilized to answer patients' questions and provide information. Leveraging technologies like Natural Language Processing (NLP), these chatbots enable patients to inquire about appointments, bill payments, and other matters, allowing medical professionals to allocate more time to their essential duties. This facilitates communication with patients about their diseases and complaints, reducing the burden on healthcare workers and benefiting both patient treatments and healthcare professionals' work.

Some healthcare institutions in the United States use chatbots for patient interaction, mental health, healthy living, and telehealth. NLP-based chatbots are utilized for straightforward tasks such as prescription refills or appointment scheduling. However, these implementations face criticism regarding patient data privacy concerns (Utermohlen, 2018).

In the United Kingdom, an artificial intelligence-based chatbot named "Babylon" is used as a triage tool to distinguish patients who need face-to-face examinations from others. Through AI-based triage, the theoretical goal is to reduce the burden on the healthcare system and direct resources to patients who are likely to have genuine medical needs (Davenport & Kalakota, 2019).

Artificial intelligence technology enables the prediction of hospital admissions by utilizing patient-related data. Software providers Electronic Health Record (EHR) systems, biosensors, smartwatches, smartphones, and information gathered by chatbots are used to tailored recommendations by comparing patient data with other effective treatment methods for similar groups. These recommendations can be presented to providers, patients, nurses, call center representatives, or care coordination coordinators (Davenport & Kalakota, 2019).

The use of artificial intelligence is particularly beneficial for preventive healthcare services. Monitoring vaccine adherence, individual weight measurements, and blood test follow-ups help alleviate both the patient and staff burden (Güzel, Akman Dömbekci, & Eren, 2022). For instance, despite the availability of free routine vaccinations in low- and middle-income countries, many children are not fully vaccinated, receive vaccinations later than recommended, or are excluded from the vaccination schedule (Chandir, Dharma, Habib, & Khan, 2018). In this context, artificial intelligence technology is employed to track the vaccinations of infants/children.

Results from a study conducted by Kazi indicate significantly lower vaccination rates in Pakistan than desired, with reasons including a lack of awareness, parental forgetfulness regarding programs, and misinformation about vaccines. The COVID-19 pandemic and social distancing measures have further negatively impacted routine childhood immunizations (RCI) due to caregivers avoiding hospitals. In 2020, an artificial intelligence-based, personalized, and free smartphone application was designed to enhance childhood immunization coverage and timelines in children in Pakistan (Kazi, et al., 2020). This free mobile application has taken significant steps for public health, aiming to mitigate the adverse effects of childhood vaccinations caused by the pandemic.

The utilization of artificial intelligence in both preventive and therapeutic healthcare services is expected to reduce disease rates and unnecessary use of medication and materials, consequently lowering the amount spent on healthcare within a country's economy (Güzel, Akman Dömbekci, & Eren, 2022). Simultaneously, substantial advancements are anticipated for public health and development.

In general health management, artificial intelligence provides speed and convenience to administrative services. The digitization process to reduce non-treatment-related administrative tasks in healthcare has matured. Effective outcomes have been achieved in administrative aspects such as human resources, material management and tracking, finance, quality, and audit. Predictions of hospital admissions using patient data, reduction in wait times in emergency services, shortened ambulance response times, accurate coordination in call centers, tracking of childhood vaccinations, reduction of time spent by healthcare professionals on administrative tasks, and improvement in patient tracking and care processes are facilitated. Additionally, the time allocated to administrative tasks can be utilized more efficiently. In conclusion, from the perspective of hospital management and resource planning, artificial intelligence systems contribute to optimizing hospital processes and enabling more efficient patient guidance, reducing wait times and improving healthcare quality.

3.1.2. Documentation Management

Artificial intelligence technology is also employed in managing administrative processes, particularly in the healthcare sector's complex realm of documentation management. Presently, healthcare professionals spend a significant portion of their working hours on non-patient-related tasks, such as preparing patient records, prescribing medications, and providing instructions for laboratory tests. Research indicates that 51% of nurses and 16% of doctors and therapists dedicate their work hours to doing bureaucratic tasks (STM). In the United States, an estimated 14% (91 billion dollars) of wasted healthcare expenditures result from inefficient management (Lallemand, 2012). At this juncture, artificial intelligence applications offer the potential to reduce the costs incurred due to bureaucratic processes in the healthcare sector.

A Harvard Business Review article published in 2018 suggested that the use of AI-supported systems for tasks such as creating patient records and prescribing medications in the United States could lead to annual savings of 18 billion USD in healthcare expenses (Kalis, Collier, & Fue, 2018).

Healthcare professionals have been liberated from the cumbersome and costly paper-based systems through the adoption of Electronic Health Record Systems (EHR). This transition ensures data organization, storage, and reuse, providing traceability of results and preventing data loss. Portable/mobile applications allow nurses to collect electronic records about patients, which are then compiled at the end of the day and transferred as summarized data in the form of voice or written reports (Balestra, 2017).

While the transition to electronic records initially simplified tasks and saved paper, the system has evolved and improved by integrating artificial intelligence technology (STM ThinkTech, 2019). For example, through Natural Language Processing (NLP), the recognition of the voices of doctors and nurses and the conversion of their speech into written text have been achieved (Akalın & Veranyurt, Sağlıkta Dijitalleşme ve Yapay Zeka, 2020). These structures resemble systems like Apple's Siri. This enables prioritizing tasks based on medical priorities through innovative recording systems.

In the context of voice-based documentation, a technology company in the United States has developed an NLP-based documentation system (Bresnick, 2018). This AI-based system provides real-time documentation guidance to healthcare personnel in 80 different languages.

AI applications contribute to cost reduction in terms of unnecessary material usage, redundant tests, and time, resulting in economic savings for hospitals. The organization, storage, and reuse of data in digital form through Electronic Health Record Systems are facilitated by healthcare professionals in documentation management. With Natural Language Processing (NLP) tools, reports based on doctors' and healthcare professionals' voice recordings can be rapidly generated through AI-based applications (Akalın & Veranyurt, Sağlıkta Dijitalleşme ve Yapay Zeka, 2020).

3.1.3. Cost and Quality Management

The literature has multiple definitions regarding what quality management in healthcare entails. The most widely accepted definition among these is the one provided in 1990 by the Institute of Medicine in the United States. According to the Institute of Medicine's definition, the quality of healthcare services is "the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge" (Kaya, Tengilimoğlu, Işık, Akbolat, & Yılmaz, 2013). Quality management plays a crucial role in maintaining standards and enhancing patient satisfaction in healthcare services. Effective quality management ensures that patients receive safe and effective care. Therefore, healthcare institutions facing high costs and risks have begun to utilize artificial intelligence.

Every healthcare organization faces certain costs. However, healthcare institutions should not view their patients solely as customers and should not approach their operations with a profit maximization motive. From this perspective, healthcare organizations should not behave like other businesses driven solely by profit. In other words, healthcare institutions should aim to reduce the costs they must bear to sustain their existence while improving the quality of healthcare services (Akalın & Veranyurt, 2020). In this regard, artificial intelligence technology is highly advantageous for both cost management and quality management in healthcare institutions.

In the United States, administrative costs in the healthcare sector in 2017 amounted to an average of $2,497 per person. When compared, administrative costs constituted 34% of the total healthcare costs (Himmelstein, Campbell, & Woolhandler, 2020). Considering the proportion of administrative costs within the total healthcare costs, reducing administrative costs holds significant potential for contributing to the overall cost reduction in healthcare services.

Artificial intelligence technology has started to make significant contributions to the quality management of healthcare institutions. Costs that are typically challenging to monitor in healthcare centers have begun to be tracked in real time. Personalized healthcare and treatment have been implemented, leading to sensitive precision medicine applications (STM ThinkTech, 2019). An example of such efforts is the artificial intelligence-based cost and quality management system developed by the Lumiata company in the United States. This artificial intelligence system allows the proactive calculation of potential risks and costs in healthcare institutions. Patient satisfaction and the quality of healthcare services are enhanced through personalized, cost-effective treatment solutions. The improvement in service quality does not increase the cost level (Lumiata, 2020).

In contemporary, medication management is an area that requires development. Even a slight deviation in the dosage of a drug can have severe consequences on the human body. It is crucial for the patient to take the correct medication at the prescribed dosage. Otherwise, detrimental outcomes may occur. Artificial intelligence plays a significant role in dose optimization and predicting adverse drug events, providing substantial benefits in enhancing patient safety and improving treatment outcomes (Martin, et al., 2022).

Artificial intelligence algorithms contribute to healthcare professionals' ability to determine personalized drug dosages for patients and predict potential adverse drug events. This reduces risks and improves patient care (Alowais, Alghamdi, & Alsuhebany, 2023). An example of this application is the CURATE.AI platform, which maps the relationship between an individual's intervention intensity (input) and phenotypic outcome (output) based solely on the individual's personal data. The CURATE.AI profile dynamically changes throughout the entire treatment process to provide the best care. This approach has been applied in the personalized determination of chemotherapy doses in cancer treatment, yielding positive results (Blasiak, et al., 2022). This personalized approach to drug therapy leads to more effective treatments and better patient outcomes (Zhang, Yixin , & Li, 2021). In this context, artificial intelligence technology can also be used in the field of pharmaceutical management.

Healthcare Supply Chain (HSC) refers to the process that ensures the timely production, distribution, and supply of pharmaceuticals and healthcare materials (Beaulieu & Bentahar, 2021). The healthcare supply chain plays a vital role in delivering healthcare products and services to patients promptly and efficiently (Sinha & Kohnke, 2009). The costs associated with this comprehensive process constitute a significant expense for hospitals. Artificial intelligence also contributes to optimizing logistical processes. An example of this application is the fully predictive algorithms in the supply system that ensure drugs and equipment are delivered on time (Fleming, 2018). According to estimates from the consulting firm Navigant, unnecessary healthcare supply chain costs amount to over 25 billion dollars annually in hospitals in the United States. Any disruption in the healthcare supply chain process can lead to critical situations. For instance, the increase in the global trade of counterfeit drugs and deviations in the control of drug and medical device stocks can result in shortages (Min, 2019). Epidemics such as SARS, Ebola, and, most recently, COVID-19 have exposed vulnerabilities in the supply chain (Araz, Choi, Olson, & Salman, 2020). Ensuring the timely and accurate use of drugs and medical devices is crucial for maximizing patient care, reducing waste in inventory, and coordinating between hospital management and stakeholders (Kumar, Mani, Jain, Gupta, & Venkatesh, 2023).

Artificial intelligence technology can be beneficial in improving healthcare supply chains. Thanks to Machine learning models, prediction of how many patients with specific complaints will visit a hospital and enable better inventory planning are conducted. Improved inventory management can lead to less waste and cost savings (Ayyildiz, 2023). Additionally, robotic process automation and machine learning technologies can be utilized to order medical products. This ensures that product stock levels are monitored and orders can be placed accordingly. Placing orders close to the depletion of stocks contributes to timely delivery, cost reduction, and increased patient satisfaction (Maddikunta, et al., 2022).

One of the most important goals of quality management is to ensure patient safety without any problems. Patient safety is defined as protecting patients from preventable harm and minimizing the risk of harm associated with the patient care process (WHO, 2015). In other words, patient safety is the prevention of negative outcomes or injuries in the hospital care process and improving or mitigating adverse events (Ramos & Calidgid, 2018).

Making mistakes is an unacceptable phenomenon in the medical field. According to a study, adverse events caused by patient care where patient safety is ignored are an important cause of death and disability worldwide (America., Kohn, Corrigan, & Donaldson, 2000). Every year, diagnostic errors occur in at least 5.1% of the population in the USA, and the annual cost of these errors exceeds 100 billion dollars (Singh, Meyer, & Thomas, 2014). Artificial intelligence technology can be used to analyze patient records to identify patients at risk, especially infection, minimizing diagnostic errors and thus ensuring patient safety (Bates, et al., 2021). In their study in 2020, Chiou and his colleagues examined 53 studies written in the literature on the effects of artificial intelligence on patient safety. As a result of this review, they concluded that artificial intelligence technology has positive effects on increasing patient safety.

As can be seen, artificial intelligence technology makes significant contributions to quality and cost management in the field of healthcare.

3.1.4. Effective Use of the Capacity of the Health Institution

Today, hospitals operate in certain capacities. Only some patients who apply to the hospital can receive immediate inpatient treatment if needed. They face the risk of a long wait or the possibility of being transferred to another hospital. Especially in emergencies, this situation has consequences that put the patient's life at risk. Therefore, efficient use of hospital capacities is essential.

Total hospital beds include convalescent (or acute) care beds, rehabilitation care beds, long-term care beds, and other hospital beds. The table below shows the number of hospital beds per 1000 people in OECD countries in 2021. Korea ranks highest with 12.8% of beds per 1000 people, followed by Japan with 12.6%. The country with the lowest number of beds per 1000 people is Mexico. As can be seen, the number of beds per patient is relatively low worldwide. In this context, the effective use of limited resources is critical.

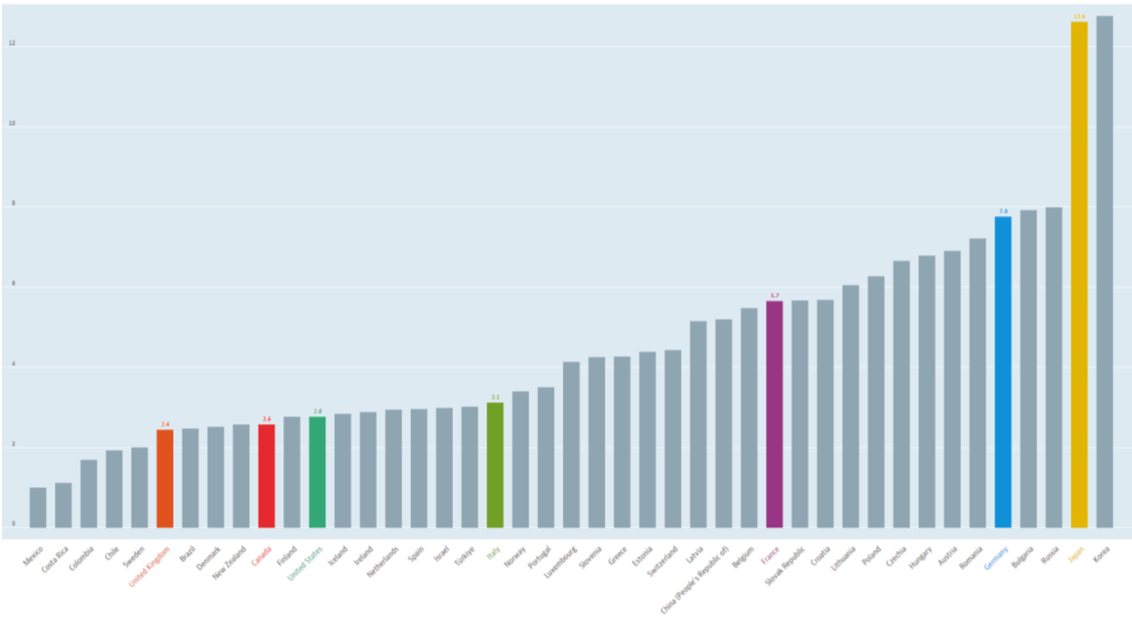


Figure 16*:Total Bed Numbers*

Source: *https://data.oecd.org/healtheqt/hospital-beds.htm*

In particular, the COVID-19 pandemic, which first emerged in Wuhan, China, in 2020 and then spread worldwide, has caused significant operational disruptions in hospitals, including intensive care units. The number of patients exceeding bed capacities has resulted in images of patients being treated in hospital corridors and on the grounds. The rapid evolution of this disease, bed capacity constraints, highly diverse patient profiles, and imbalances in healthcare supply chains still pose a challenge for policymakers.

In this context, the artificial intelligence model was used to predict how likely a Covid patient would be to be admitted to the intensive care area in the next few hours, during the pandemic period when demands for intensive care increased. In line with the estimates obtained, healthcare personnel determined the number of intensive care hospitalizations within a certain period and were able to make an estimate of the occupancy rate by comparing the intensive care capacity and the number of patients. The study in question was conducted by Barrios et al. in a Spanish hospital, and it was concluded that artificial intelligence technology helps healthcare personnel in their decision-making processes and ensures efficient use of hospital capacity. It has been proven that the average bed waiting time decreased from 32.42 to 48.03 minutes after the intervention (Ortiz-Barrios, et al., 2023). Artificial intelligence-based systems provide a valuable area of use in effectively using the limited number of hospital beds in epidemics that shake the world, such as COVID-19 (Akalın & Veranyurt, 2021).

Artificial intelligence technology is utilized to deliver limited services in hospitals efficiently. Since 2016, the Command Center at Johns Hopkins in Baltimore/Maryland has received approximately 500 messages per minute from 15 personal computer sources within the healthcare system each day. This enables real-time monitoring and forecasting of healthcare personnel's working hours and the status of physical facilities (such as patient beds). The artificial intelligence system used in the command control center ensures that the most accurate decisions are made to maximize hospital capacity. High-risk patients can receive prompt interventions through this AI system, leading to notable outcomes reported by Johns Hopkins. The findings indicate a 30% faster allocation of beds to emergency room patients and a 70% reduction in delays in transfers from operating rooms (Lee & Yoon, 2021).

In addition to real-time monitoring of available bed capacities in hospitals, artificial intelligence technology is employed to calculate the probability of readmission for discharged patients (Akalın & Veranyurt, 2021). Hospital readmissions imply increased healthcare costs, adding extra pressure to the healthcare system and diminishing the effective use of limited resources (Kripalani, Theobald, Anctil, & Vasilevskis, 2014). In a hospital in Singapore, machine learning models were utilized to predict the probability of patients being readmitted within 30 days of discharge. This approach saved 3,200 patient bed days annually, with the 30-day readmission rate decreasing from 11.7% in 2017 to 10.1% in 2019 (Wu, et al.).

As evident, artificial intelligence technology contributes to the more efficient use of hospital capacity, allowing for cost savings.

3.1.5. Remote Preventive and Complementary Health Services

Artificial intelligence's use and continuous development in the healthcare system introduce various complementary healthcare services aimed at preventing issues. Examples include virtual nursing assistants, dosage error reduction applications, less invasive surgeries, customer service chatbots, and virtual health assistants.

Patients utilizing AI-based virtual nursing assistants have access to support responses from nurses at any time of the day. AI-powered chatbots, applications, or other interfaces act as virtual nursing assistants, answer medication-related queries, transmit reports to doctors or surgeons, and help patients schedule appointments with doctors. These AI-driven systems alleviate the workload of clinical staff, allowing them to dedicate more time directly to patient care, where human judgment and interaction are most crucial.

In addressing the reduction of dosage errors, AI can be employed to identify errors in how patients self-administer medications. An exemplary study published in Nature Medicine revealed that up to 70% of patients do not take insulin as prescribed (Zhao, Hoti, Wang, Ragghu, & Dina, 2021). An AI-supported tool in the background (similar to a Wi-Fi router) can be utilized to flag errors in how a patient applies insulin pens or inhalers.

Another complementary service arising from the active use of artificial intelligence is the occurrence of less invasive surgeries. AI-supported robots can be employed to work around delicate organs and tissues to reduce blood loss, infection risks, and postoperative pain (IBM Education, 2023).

Chatbots, developed using technologies such as Natural Language Processing (NLP), enable patients to inquire about appointments, bill payments, and more. Chatbots also communicate with patients about diseases and symptoms, helping alleviate the burden on healthcare professionals. Additionally, chatbots assist in providing patients with necessary solutions, allowing healthcare experts to focus on other critical tasks (Intellipaat, 2023).

Finally, virtual health assistants are responsible for responding to routine patient questions via calls and emails, managing patients' medical information, processing sensitive data, scheduling appointments with doctors, and sending follow-up and clinic appointment reminders. Offering a personalized experience for managing health and resolving concerns, virtual health assistants prove to be among the most practical applications of artificial intelligence in the healthcare sector. They benefit both patients and healthcare professionals by reducing the frequency of hospital visits (Intellipaat, 2023).

3.1.6. Eliminating Irregularities in Healthcare System

The risky, asymmetric information-based, and multi-actor structure of health services (such as pharmaceutical companies, health service providers, medical device and material suppliers, pharmacies, health insurance companies, and private law legal entities that produce or offer human medical products) makes the health sector a complex and profitable field. At the same time, this profitability also causes fraudulent activities (Avcı & Teyyare, 2012, pp. 205-208). Fraudulent activities that occur are not only caused by healthcare providers. It has been observed that patients, other actors, and service providers cause irregularities in the system.

Internationally, efforts have been made to uncover and prevent fraudulent activities in this sector. For instance, the European Healthcare Fraud and Corruption Network (EHFCN) has developed a 'Waste Typology Matrix' to facilitate the comparability of healthcare fraud across different countries. EHFCN distinguishes between error, abuse, waste, fraud, and corruption. *Waste* is an umbrella term encompassing a series of phenomena causing financial losses in healthcare services. Healthcare service fraud is briefly defined as "receiving payment for healthcare services one is not entitled to by acting against regulations, knowingly making false statements, or distorting the truth" (Bauder & Khoshgoftaar, 2017).

Irregularities in healthcare services occur worldwide in various intensities and forms. Although it is not possible to determine their share in total healthcare expenditure precisely, it is estimated that these irregularities constitute approximately 10% of total healthcare spending globally (Thaifur, Maidin, Sidin, & Razak, 2021, p. 441).

In the United States, one of the factors leading to the increase in healthcare costs is fraud, one of the types of irregularities in healthcare services. It is estimated that the U.S. will spend about twice the required amount on billing and insurance-related (BIR) costs. This administrative burden roughly equates to around $248 billion of the annual expenditure surplus. Most of these costs are associated with unnecessary procedures, fraud, waste, non-value-added or low-value-added tasks, and lack of stakeholder collaboration (Intellipaat, 2023).

On the other hand, looking at European countries, according to EHFCN data, which was established in 2005 to combat fraud in the field of health, it is estimated that losses due to fraud and corruption in Europe reach up to 56 billion Euros per year, or more than 5% of national health budgets (Vinke & Cylus, 2011, p. 14).

Table 2:*Spectrum of Irregularities*

	TYPES OF IRREGULARITY			
	Error	**Abuse**	**Fraud**	**Corruption**
Definition	Obtaining any benefit improperly by unintentionally violating a rule	Intentionally bending a rule/guideline or taking advantage of the absence of a rule/guideline to gain unfair advantage	Gaining benefit by deliberately violating a rule	Obtaining benefits through abuse of authority with the participation of third parties
Sample Cases	Accidentally billing an examination that was not paid for by the reimbursing institution Inadvertently billing a green field examination instead of an emergency outpatient clinic examination Unknowingly billing for the most expensive antibiotic for a simple infection	Requesting and billing ECGs from patients whose clinical indication is not clear.	Including out-of-scope interventions for aesthetic purposes in different scopes and billing them to the institution that will reimburse them.	Receiving a commission from a medical company for a cardiac pacemaker. Getting a kickback from a laboratory by ordering unnecessary blood tests.
Sanctions (Depending on the Situation of the Case)	- Informing - Expostulating - Refund Request - Administrative Fine	- Set rules in the system - Refund Request - Administrative Fine - Disciplinary punishment	- Refund Request - Administrative Fine - Disciplinary punishment - Imprisonment - Criminal Sanctions	- Refund Request - Administrative Fine - Disciplinary punishment - Imprisonment - Criminal Sanctions - Compensation claim

A study by LexisNexis Risk Solutions revealed that an average of $8.6 million is lost annually due to fraud in health insurance coverage as well as fraudulent activities (e.g. kickbacks, misrepresentation of patient eligibility) by pharmaceutical companies. It seems unlikely that fraud in drug purchases will be detected because criminals hide their behavior. In addition, irregularities caused by the use of stolen identities, forged documents and similar illegal documents cause losses of millions of dollars (VAMSTAR, n.d.).

Fraud and abuse are another notable reason for the high cost of healthcare. This category includes the cost of additional audits and regulations to detect irregularities, as well as fake medical bills and scams. A study conducted by Berwick and Hackbarth estimated that fraud and abuse added $82 billion to $272 billion to U.S. healthcare costs in 2011 (Healtdatasharing, n.d.).

The advent of artificial intelligence (AI) solutions is believed to significantly contribute to the detection and substantial reduction of fraudulent attempts in addressing irregularities in the healthcare sector. Developments in this context suggest that AI tools not only reduce costs but also expedite administrative healthcare operations, such as the transcription of medical notes, by eliminating manual data entry, correcting human errors, and automatically processing electronic health records (EHR).

Previously, opportunities for errors and fraud in prescriptions were abundant, allowing dishonest doctors or patients to manipulate these documents. However, with the influence of artificial intelligence, pharmacy errors and fraudulent activities by doctors and patients can now be reduced via technical systems.

One way to improve the detection of fraudulent activities, such as fraud, ia a form of artificial intelligence program called Neural Network Analysis. Through machine learning, neural networks can rapidly analyze large amounts of data and recognize patterns or indicators of criminal behavior. For instance, a company used a neural network to scan millions of invoices in just six months, achieving a nearly 50% reduction in error rates.

AI-supported data mining techniques that identify anomalies in health insurance and insurance claims can save an estimated $17 billion annually in the United States (Kalis, Collier, & Fue, 2018). Thanks to artificial intelligence, it is envisaged that waste in healthcare services will be prevented and economic losses will be reduced, resources will be used more efficiently, access to healthcare services will increase, and healthcare research and development projects will be financed more effectively.

3.2. AREAS OF USE OF ARTIFICIAL INTELLIGENCE FOR CLINICAL PURPOSES

3.2.1. Public Health Management

In 1923, American doctor Winslow defined public health as a scientific discipline that:

- Improves environmental health conditions through organized community efforts,
- Provides information to individuals for preserving their health,
- Prevents communicable diseases,
- Establishes health organizations for early diagnosis and preventive treatment of diseases,
- Establishes a lifestyle that allows every individual to lead a healthy life,
- Acts as a branch of science that prevents diseases extends life expectancy, and enhances physical and mental health and work capacity.

Artificial intelligence (AI) technology is utilized in various areas, such as raising awareness about diseases, conducting screening tests for a large audience, preventing diseases, and tracking and preventing epidemic diseases. AI-based applications can ensure easy and cost-effective access for individuals. Additionally, it can assist individuals in monitoring and managing chronic diseases like diabetes and hypertension

(Jungwirth & Haluza, 2023). AI can enable remote early diagnosis and treatment and provide emotional support for mental health, eliminating the need for individuals to go to the hospital (Abd-Alrazaq, et al., 2019). AI can also remind individuals to undergo health screenings or vaccinations, contributing to disease prevention and increased life expectancy. Using AI in public health can enhance health outcomes, improve disease surveillance, and reduce healthcare costs (Corpuz, 2023).

In the field of public health, artificial intelligence (AI) contributes significantly to epidemiology, a branch of medicine that analyzes the frequencies of diseases, outbreaks, and overall health conditions, aiming to understand their origins and prevent them. The ability of AI technologies to detect patterns and anomalies within data, make predictions, and perform continuous and rapid tasks directs the application of this technology towards "surveillance," which involves the continuous monitoring of diseases occurring in society (Kucukali, 2021). The physical documentation of patient health records on paper complicates disease tracking. Moreover, the complete analysis and examination of records on paper are limited. AI technology presents a valuable application in creating patterns of disease distribution, detecting changes in these patterns, and providing early warnings, when necessary, thanks to successful predictive systems (Kucukali, 2021). In this context, natural language processing techniques can be employed. Natural language processing aids in extracting information about disease outbreaks, determining the trends of disease spread, and identifying correlations between public health data and socio-economic conditions, among other factors (Jungwirth & Haluza, 2023). The Public Health England Surveillance System has started to utilize machine learning techniques to determine whether the events detected in the surveillance system pose a significant threat to public health (Lake, et al., 2019). As the current state of public health is better understood, decision-making and policy-making processes can be created for better health outcomes.

Real-time syndromic surveillance based on social media data is currently of great interest (Charles-Smith, et al., 2015). Data obtained from social media and patient records from hospitals can be processed and analyzed using AI technology. An observation tool named

SENTINEL has been developed using natural language processing and neural network algorithms. It processes and analyzes millions of data, including tweets primarily from the United States, to identify potential outbreaks and provide real-time predictions (Şerban, Thapen, Maginnis, Hankin, & Foot, 2019). It issues advance warnings against diseases and outbreaks based on its findings.

Artificial intelligence's (AI) contribution to preventive health is invaluable (Kucukali, 2021). As observed, the detection of general health issues, previously identified solely through analyses by physical resources and healthcare personnel in past years, is now conducted with AI technology, reducing human errors and enabling the analysis of more extensive datasets. By utilizing diverse data, individuals at risk can be identified. Moreover, an early warning system facilitates early intervention. This helps prevent issues arising from intervention delays, leading to cost savings in hospital-related expenses (Dickson, 2018). One of the most significant outcomes of this situation is the reduction of the cost of public health management. Additionally, it has a relieving effect on the healthcare system and contributes to overall well-being (STM ThinkTech, 2019).

The "Health and Human Services Research Institute," affiliated with IBM, supports governments in enhancing community health and service delivery. It ensures the correct alignment of the demand for healthcare services with the supply of health services. In this process, the artificial intelligence named Watson, emerging with the slogan "Empowering heroes, transforming health," is employed.

The artificial intelligence named "Zeus," developed by the U.S.-based technology company CareSkore, monitors individuals' health conditions and reduces the risks for healthcare institutions and insurance companies. Through AI developed by CareSkore, demographic, behavioral, and socioeconomic data are analyzed alongside individuals' clinical data. After the analysis, a health profile is created, revealing individuals' disease risks. When a new disease risk emerges, individuals receive mobile messages about protecting their health, and healthcare institutions and insurance companies are alerted to take precautions. Additionally, data such as whether the patient will attend appointments, the risk of death, and medication habits are conveyed to insurance companies and healthcare centers (Mannes, 2016).

Artificial intelligence technology significantly contributes to public health by increasing the sensitivity and selectivity of laboratory tests (Kucukali, 2021). For example, in Chicago, machine learning techniques were employed to predict whether the bacterium Escherichia coli (E. coli) levels on beaches pose a risk to swimmers. Although the results are obtained later compared to PCR tests, there is a significant increase in sensitivity. A model was created that provides beach managers with better predictions at lower costs and less complexity than PCR tests (Lucius, et al., 2018).

Ensuring the proper intervention is administered to the right individuals at the right time is highly crucial (Khoury, Iademarco, & Riley, 2016). If these three conditions cannot be met simultaneously, there will be both cost and time losses in the treatment, and results leading to loss of human lives may occur. Therefore, artificial intelligence (AI) technologies can be employed in public health to identify those who need it most and provide the most accurate services. For instance, in a study conducted by Chu and colleagues to reduce the rapidly popularizing use of hookah, which leads to various health issues, especially among the young population, machine learning techniques were utilized to collect tweets about "hookah" on Twitter for six months. By using the datasets obtained from Twitter, they identified specific target audiences that would be most responsive to targeted campaigns for public health officials. Consequently, public health campaigns targeting the most appropriate individuals to reduce hookah usage were launched (Chu, Colditz, Malik, Yates, & Primack, 2019).

Similar data and natural language processing methods are also used to identify individuals at risk of suicide (Roy, et al., 2020). In other words, through AI technology, specific subgroups of the population in need of particular health services are better defined, and the potential effects of policy changes are predicted to enhance population health management (Fisher & Rosella, 2022).

With globalization, the occurrence of pandemic diseases and their spread rates have increased. Over the years, the world population has had to cope with various pandemic diseases. The Severe Acute Respiratory Syndrome (SARS) epidemic emerged in 2003, marking the first pandemic that profoundly affected public health. Other pandemics the world population has had to contend with include H1N1 influenza, commonly known as swine flu, the Ebola virus, polio, and the Zika virus. Lastly, in 2019, the Covid-19 pandemic was declared an internationally concerning public health emergency by the World Health Organization (Wang, et al., 2022). These pandemics have led to both severe global public health crises and profound impacts on the world economy. Post the Covid-19 pandemic, the lifestyles of societies have changed, lockdowns have been enforced, daily life has been directly affected, and many businesses have faced bankruptcy. Additionally, chip and vaccine crises have emerged globally.

In dealing with the pandemic, artificial intelligence technology has dramatically improved COVID-19 screening, diagnosis, and prediction, providing timely, reliable, and efficient results. Studies have even shown that it performs better than humans in certain healthcare tasks (Sipior, 2020). Another study by Vaishya et al. revealed that artificial intelligence applications were used in seven important areas for the Covid-19 epidemic: early detection and diagnosis of infection, monitoring of treatment, case and death prediction, development of drugs and vaccines, reducing the workload of healthcare workers, and preventing the disease (Vaishya, Javaid, Khan, & Haleem, 2020). In addition, efforts were made to prevent the spread of the virus thanks to artificial intelligence-based geographical location tracking programs (Akalın & Veranyurt, Sağlıkta Dijitalleşme ve Yapay Zeka, 2020). For example, in Greece, artificial intelligence called “Eva” helped identify high-risk travelers for COVID-19 testing. If such developments had not occurred, the world would have dried up later than this process. Each day spent fighting the epidemic could continue to put tremendous pressure on the budgets of both individuals and states.

3.2.2. Early Diagnosis and Emergency Response

Detecting a disease or any health issue in an individual before clinical signs and symptoms emerge or before the disease progresses and begins to impact one's life negatively is termed "early diagnosis." Early diagnosis enables the initiation of treatment in the early stages of the disease.

In a study conducted in Baltimore, USA, individuals were asked about any health issues they might have. Subsequent research based on the responses revealed that among individuals who claimed not to have health complaints, 37% had hypertension, 27% had high blood sugar, and 20% had cardiovascular diseases (Bölükbaş, 1993). This study indicates that the known case numbers in the community are significantly lower than undetected cases.

Diagnosis is the first step in the initiation of disease treatment. Therefore, to prevent and cure a disease, it is crucial first to diagnose the existing condition. Delays in the diagnostic stage can lead to the insidious spread of the disease and a decrease in the chances of successful treatment. Early diagnosis is crucial for treatment success and the patient's survival. For instance, if malignant melanoma, a type of skin cancer, is diagnosed when its thickness is below 1 millimeter, the 5-year survival rate for patients is 95%. However, for patients at the melanoma stage with a thickness exceeding 4 mm, the 5-year survival rate drops significantly to 45% (Balch, et al., 2001). In other words, early diagnosis of a disease carries vital importance.

Artificial intelligence technology, with its ability to process a large quantity and variety of data more quickly, is employed in the early diagnosis of diseases and determining the correct treatment method, making significant contributions to the medical field. This situation prevents unnecessary procedures on patients and avoids incorrect or unnecessary treatment applications. Moreover, treatment methods performed in the advanced stages of a disease are often more costly. Artificial intelligence technology helps prevent high healthcare expenditures through early diagnosis, resulting in cost savings.

Cancer is one of the most significant challenges globally today. According to the World Health Organization's data, in 2020, 19,292,789 people worldwide were diagnosed with cancer, and a total of 9,958,133 people died due to cancer. As previously mentioned early diagnosis is vital for the success of treatment in cancer patients. Early cancer detection significantly increases the chances of success in treatment and survival. The earlier the cancer diagnosis can be made, the more influential the treatment is likely to be. Artificial intelligence is utilized for the early diagnosis of cancer. For example, artificial intelligence has been employed in the United States to interpret mammogram test results. The results indicate that the artificial intelligence system diagnoses at a rate 30 times faster than doctors and with 99% accuracy. Achieving a correct result rate of 99% has reduced the need for biopsies (Macdonald, 2016). The decrease in the need for biopsies has also led to a reduction in laboratory costs.

From 2012 to 2022, over ten years, the number of annual melanoma cases has increased by 31% due to partially increased exposure to UV rays. As mentioned above, early diagnosis of skin cancer cases significantly increases the survival rate (In early diagnosis, the five-year survival rate is %95). Advanced-stage melanoma patients face a serious risk of mortality (Cancer Research Institute, 2016). Convolutional Neural Network (CNN), a deep learning system, is utilized to diagnose skin cancer. In a study conducted to detect benign and malignant skin lesions using CNN, a total of 58 dermatologists from 17 countries participated in a mutual test. The findings were published in the medical journal Annals of Oncology. According to the research, while dermatologists diagnosed skin cancer with 86.6% accuracy, CNN achieved an accuracy rate of 95% (BBC News, 2018). CNN reduces the time and costs involved in diagnosing skin cancers (Alquran, et al., 2017). Thanks to artificial intelligence technology, financial costs are reduced, and diagnoses are made more efficiently, thereby reducing mortality and morbidity rates (Jutzi, et al., 2020).

Furthermore, a mobile application named "SkinVision" has been developed to detect skin cancer based on photos taken by the individual. Users can learn about the risk status of skin lesions within 30 seconds without the need to go to the hospital. According to the findings from studies, the algorithm detects 95% of skin cancers in the early stages (Freeman, et al., 2020). SkinVision reduces the number of primary and secondary healthcare visits to hospitals. Reducing unnecessary hospital visits can result in up to a 50% cost savings (Peverelli & Feniks, 2017).

The global population is gradually aging. According to reports from the United Nations Ageing Program and the Centers for Disease Control and Prevention (CDC) in the United States, the number of people aged 65 and over worldwide, which was 420 million in 2000, is expected to reach 1 billion by 2030 (Ng, Cheung, Milea, & Ting, 2021). This means that 12% of the world's population will be 65 and over. With aging, the incidence of Alzheimer's disease also increases. In the United States, an estimated 6.7 million Alzheimer's patients aged 65 and over live, and it is expected that the number of Alzheimer's patients in the United States will increase to 13.8 million by 2060 (Alzheimer's Association, 2023). The progression of Alzheimer's disease often leads individuals to require assistance in meeting their daily needs, increasing dependency on others. Frequently, specialized care is necessary. Due to the lack of a complete cure, patients and their immediate surroundings bear the lifelong cost of care. Early diagnosis of Alzheimer's is crucial for identifying patients suitable for disease-modifying drugs and improving access to non-pharmacological preventive interventions (Fristed, et al., 2022). Otherwise, patients may unnecessarily incur expenses for non-therapeutic drugs. Early diagnosis and treatment are essential for enhancing patient outcomes and developing more effective treatments (Vrahatis, et al.).

Artificial intelligence technology has facilitated the early detection of Alzheimer's disease. A deep learning algorithm developed for the early diagnosis of Alzheimer's disease, using 18-fluorodeoxyglucose PETCT, enabled diagnosis approximately 75 months before clinical diagnoses (Ding, et al., 2019). The Alzheimer's Association (2018) stated that early Alzheimer's detection saved 7 trillion dollars.

Diabetes is one of the most dangerous chronic diseases that can lead to other serious complications. According to the International Diabetes Federation (IDF) 2021 data, there are approximately 537 million diabetic patients worldwide. It is assumed that the number of diabetic patients will reach 643 million by 2030 and 783 million by 2045. In 2021, 6.7 million people died due to diabetes.

Several factors, such as a sedentary lifestyle, poor nutrition, and kidney failure, contribute to the onset of diabetes. Moreover, accessing insulin, the medication used to treat diabetes is quite expensive. Therefore, diabetes affects impoverished countries more, both due to the triggering of diabetes by poor living conditions and the difficulty of accessing medication. According to research, a 10-year-old child with type 1 diabetes in a low-income country has an average life expectancy of only 13 years (Perera, 2022).

Furthermore, diabetes triggers many other diseases, such as heart attacks, blindness, and kidney diseases. Early diagnosis of diabetes not only helps prevent many diseases but also supports sustainable development (Chauhan, Rawat, Malik, & Singh, 2021). When diabetes is detected early, it can be effectively overcome with high accuracy. A method proposed by Woo and colleagues, which predicts the likelihood of detecting diabetes in its early stages through machine learning, achieved an accuracy of 84% (Woo, Andres, Jeong, & Shin, 2021). In summary, Machine Learning (ML) approaches are highly effective in the early detection and prediction of diabetes (Chauhan, Rawat, Malik, & Singh, 2021).

Çalışkan and Çınaroğlu concluded in their study that studies determining the cost-effectiveness of diagnosing diseases using artificial intelligence compared to conventional diagnosis are most related to tooth decay, atrial fibrillation, and diabetic retinopathy (Çalışkan & Çınaroğlu, 2023). Early detection of diabetic retinopathy, a disease that leads to vision loss due to diabetes, prevents diabetic patients' future vision loss. Thus, through artificial intelligence technology, early diagnosis helps improve the quality of life and prevents dealing with lifelong treatment expenses.

The Chinese firm Airdoc has developed a device that processes retinal images to enable the early diagnosis of various chronic diseases. Using retinal images, the device can detect

30 diseases, including diabetes, hypertension, and various eye conditions. The company continues to increase the number of diseases diagnosed early (Spencer, 2018).

In today's world, the popularity of wearable technology products such as smartwatches, smart glasses, electronic clothing, and personal video recording devices is continuously increasing. While wearable technologies are preferred for various reasons, their most significant benefit to individuals is in the health field. Wearable technologies enable the recording of individuals' movement data, monitoring of sleep status, measurement of physiological data such as oxygen saturation, and long-term tracking of parameters like heart rate. This facilitates the early diagnosis of chronic diseases such as cardiovascular diseases, hypertension, diabetes, and obesity (Majumder, Mondal, & Deen, 2017).

The increasing awareness of health in society and the rising costs of healthcare lead people to turn to wearable technology (Ananthanarayan & Siek, 2012). For instance, smartwatches like FitBit and iWatch have become more popular than regular watches due to their health benefits. Through artificial intelligence technology, smartwatches instantly collect personal data, such as users' sleep patterns, burned calories, and heart rates. Early disease diagnosis, regular patient monitoring, and personalization of the health and pharmaceutical sectors are facilitated through the data collected, improving the overall healthcare system.

Wearable devices allow individuals' real-time collection of personal health-related data, enabling early diagnosis and effective treatment planning (Tezcan, 2016). Moreover, the data obtained from these devices facilitate the recording of epidemiological data for improving public health. They contribute to the early detection of epidemic diseases, consequently reducing healthcare costs (Pentland, 2005).

Early intervention is as crucial as early diagnosis in dealing with diseases. Artificial intelligence technology is also used for early intervention. In London, people can use chatbots in AI-based smartphone applications, in addition to emergency phone lines, during urgent situations (Burges, 2017).

Danish technology company "Corti.ai" has developed an artificial intelligence-based application that analyzes calls to emergency hotlines to detect whether the caller is experiencing a heart attack (STM ThinkTech, 2019). According to tests, Corti.ai's AI has an accuracy rate of 93% in correctly detecting heart attacks, while the accuracy rate for first responders is 73% (Marr, 2018). This allows distinguishing between accurate and inaccurate calls, enabling emergency response teams to reach the correct patient without wasting time, representing a highly cost-effective application.

Studies indicate that artificial intelligence technology has significantly increased the healthcare sector's early diagnosis and emergency intervention capabilities. Early and accurate diagnosis enables the initiation of an effective treatment process, eliminating life-threatening risks in many diseases. The advancements in artificial intelligence technology also contribute to time savings for doctors, addressing the current shortage of doctors in the healthcare sector. Additionally, there is a noticeable reduction in unnecessary and high healthcare costs for both patients and the government.

3.2.3. Evaluation of Radiology Images

Today, one of the areas where artificial intelligence technology demonstrates its highest level of success in the healthcare field is the evaluation of images in radiology. In this regard, machine learning and deep learning are the most commonly used artificial intelligence techniques to evaluate images in radiology.

It is estimated that around 450 million X-rays, ultrasounds, tomographs, and MR scans are performed annually in the United States. Due to the misinterpretation of images taken from technological devices by healthcare professionals, approximately 90 million patients receive incorrect diagnoses. Misdiagnosis leads to both the loss of many lives and billions of dollars in damage to the healthcare system (STM ThinkTech, 2019). Additionally, the need for repeated imaging due to the initial failure to make an accurate diagnosis increases costs.

The American company Enlict, through its artificial intelligence application, saves nearly $3 billion in the healthcare system annually. With deep learning, a vast amount of data is quickly collected and analyzed. This enables the interpretation of medical images to occur in milliseconds. Moreover, the developed artificial intelligence can detect anomalies that are difficult to notice by the human eye. The findings indicate that the artificial intelligence system detects lung cancer with a 50% higher accuracy compared to radiologists (STM ThinkTech, 2019).

The IBM Watson Imaging Clinical Review program evaluates images taken from patients to make diagnoses and shares the results with physicians. Thanks to IBM Watson, which allows radiologists to interpret radiological images every two seconds, physician burnout is prevented (Uçar, 2018).

In 2021, Schwendick and colleagues conducted a study analyzing the cost-effectiveness of artificial intelligence in radiological image evaluation. According to the results obtained from the study, artificial intelligence technology proved to be more cost-effective and efficient in diagnosing radiographic dental caries in the majority of all patients (>77%) compared to physicians using the classical method (Schwendicke, Gomez Rossi, Rojas-Perilla, & Krois, 2022).

Artificial intelligence technology to evaluate images in radiology has eliminated the waiting time for the images obtained from medical technologies during the disease process. This has resulted in time and cost savings in disease diagnosis. Simultaneously, it has reduced the workload on doctors. Different studies have proved that the performance of artificial intelligence-based analysis software in the field of radiology is better than the performance of physicians (Kubota, 2017). When the performance of physicians and artificial intelligence-based applications is compared regarding the evaluation time of radiological images, there is a significant difference. The number of radiological images a person can look at is limited. Statistics show that an experienced healthcare professional who has been practicing radiology medicine for approximately 40 years examines nearly 225 thousand MR/CT images in total throughout his career (Mintz

& Brodie, 2019). In another study conducted in 2018, chest radiography taken in 420 patients was evaluated by deep learning and radiologists. As a result of the study, deep learning evaluated the chest radiography of 420 patients in only 1.5 minutes. Radiologists were able to evaluate the chest radiographs of 420 patients in an average of 240 minutes (Rajpurkar, 2018). As can be seen, there is a very high difference between the two evaluation periods.

Artificial intelligence-based applications can perform millions of scans with high accuracy in a short time. In the international competition called Kaggle Data Science Bowl in 2017, the findings obtained in lung cancer screening thanks to machine learning gave 80% to 95% accurate results (Kann, Thompson, & Dicker, 2019). Thanks to this revolutionary technology, medical images can be analyzed much faster and more accurately than the average person (Mintz & Brodie, 2019). Thus, doctors can save both time and workload.

3.2.4. Tracking Test Results

In today's healthcare system, after patients receive an examination at the hospital, they must first schedule electronic appointments for each required test. After completing the tests and obtaining the results, they need to schedule another appointment to show the test results to the doctor. Especially in emergencies, a system that necessitates reappointments poses a significant risk to human health in terms of time. It is vital for doctors to examine patients' tests as quickly as possible to intervene promptly. Artificial intelligence technology has facilitated solutions to this situation.

Chronic diseases are among the most common causes of death worldwide. As confirmed by the United Nations and the World Health Organization, chronic diseases pose a serious health problem for humanity. In the 21st century, chronic diseases are among the most crucial health challenges that defy advancement. Approximately 15 million people aged 30-70 die each year due to chronic diseases (World Health Organization (WHO), 2018). Continuous monitoring of the development of diseases is necessary. This requires individuals with chronic diseases to visit doctors continually. Patients must bear transportation expenses to go to the hospital, and waiting at the hospital is a stressful situation for both time and the individual. This situation becomes a financial and time burden for patients who are already struggling with costs such as tests and medications. In this context, wearable devices equipped with artificial intelligence technology that reduce the need for patients to go to the hospital are highly beneficial. With AI technology, doctors can monitor patients without needing to go to the hospital, even without being in the same city or country as the doctor. After the patient's consent, test results can be accessed by doctors regardless of location and time (Akalın & Veranyurt, Sağlıkta Dijitalleşme ve Yapay Zeka, 2020).

Regular monitoring of personal health data such as pulse and blood pressure in heart patients, especially, allows for the early detection of cases such as heart attacks and enables early intervention (Johnson, et al., 2018). For example, patients with chronic heart conditions had to take electrocardiograms (ECGs) and visit the hospital regularly to calculate the risk of a heart attack. Thanks to artificial intelligence technology, people can now monitor their heart rhythms in their daily lives and share the data with their doctors through telehealth. The Apple Watch, developed by Apple, evaluates a person's ECGs waves throughout the day and provides a warning in case of rhythm irregularities. Studies have shown that the DeepHeart algorithm developed by Apple Watch accurately detects cardiac rhythms by 97%. Additionally, the application directs patients to transmit their health data directly to the doctor through telehealth.

Individuals with chronic illnesses can monitor their health status in real-time without the need to go to the hospital and automatically transmit changes in body functions and test results to their doctors. This way, both tests are conducted without going to the hospital, and health data is instantly transmitted to the doctor. Thus, such patients are relieved from the constant expense of going to the hospital, and doctors save time. Moreover, emergencies can be diagnosed early, allowing timely intervention.

Thanks to artificial intelligence, patients' treatment processes can be better monitored. AI enables healthcare professionals to provide timely, more effective, and personalized treatment to individuals. One application that allows doctors to monitor patients' test results in real-time is "Streams." Developed by Google and used in the UK, the "Streams" application allows patients to quickly access their medical test results and share them with their doctors. If the application detects a deterioration in the patient's health, it immediately notifies doctors and nurses through a smartphone application that detects anomalies (STM ThinkTech, 2019). This facilitates early intervention in emergencies. Findings indicate that the Streams application at the Royal Free Hospital in the UK saves two hours and allows nurses to focus more on patient care (Hern, Royal Free breached UK data law in 1.6m patient deal with Google's DeepMind, 2017).

LabCorp, a US-based medical laboratory company, offers patients an online platform called Patient Portal. In the Patient Portal, patients can quickly view their own medical test results and health data. The artificial intelligence technology used in the portal explains test results to individuals and draws attention to test results that may pose a risk. Moreover, it provides medical recommendations and treatment options based on test results. This allows patients to have better information about their health status and securely share their health data with doctors (Labcorp Patient, n.d.).

Thanks to artificial intelligence technology, test results related to a patient can be shared with relevant doctors, regardless of their location in the world. This allows for early intervention for the patient. Additionally, since patients' medical history is stored, it contributes to the planning of accurate and personalized treatment. It strengthens communication between doctors and patients. Developments in artificial intelligence technology are also economically beneficial. It reduces the cost of patients constantly going to the hospital and saves time for healthcare professionals. AI prevents unnecessary congestion in hospitals, reduces the burden on hospitals, minimizes resource consumption, and decreases wasted time and effort in unnecessary medical interventions (Ali, et al., 2023).

3.2.5. Treatment and Artificial Intelligence Supported Robotic Surgery

Accurate diagnosis and appropriate treatment are crucial for a patient's survival. Incorrect diagnoses and subsequent improper treatments can lead to fatal outcomes. According to a study conducted at Johns Hopkins University, approximately 371,000 people die each year in the United States due to diagnostic errors, and an additional 424,000 individuals suffer from permanent disabilities such as brain damage, blindness, limb or organ loss, or metastatic cancer (Newman-Toker, et al., 2023). Incorrect diagnoses also bring about incorrect treatment methods, and the cost of erroneous treatment per individual is considerably high. This situation significantly increases healthcare costs. Achieving correct diagnoses and treatments is paramount for a person's recovery and preventing a surge in healthcare expenses. Big data analytics is estimated to save between $300 billion and $450 billion annually in healthcare costs in the United States alone (Kayyali, Knott, & Van Kuiken, 2023).

The rapid development and dissemination of artificial intelligence (AI) technology are transforming treatment options and introducing new approaches to patient care in the healthcare sector. With the advancement of AI technology, personalized, comprehensive, and precise treatment options are now being offered to patients.

AI provides detailed information about various treatment options, enabling informed decision-making about treatment plans. Surgeries are now performed using AI-assisted robots. Additionally, AI technology is actively utilized in treatment processes such as examining pathology results and determining personalized drug treatments.

The use of robotic technology in the healthcare field began in 1985 with the use of the "PUMA" robot for biopsies (Porto & Çatal, 2021). With the advancement of artificial intelligence (AI) technology, the use of AI-assisted robots has increased, leading to more precise and secure surgical procedures. Since 2000, the "Da Vinci Robotic Systems" developed by Intuitive Surgical Inc. has been widely used in surgeries in 70 countries (Liu, et al., 2021). ZEUS Robotic Systems ranks second in terms of usage. These robots are employed in surgeries for various diseases, including urology, general surgery, and cancer operations (STM ThinkTech, 2019).

Today, robots equipped with AI technology assist surgeons or perform surgeries independently in many surgeries. According to The Guardian, in 2022, a robot named Star successfully performed small intestine surgery on four pigs without human assistance. According to Dr. Axel Krieger from Johns Hopkins University in the United States, this robot is expected to perform surgeries on humans independently, without human assistance, within the next five years.

Integrating preoperative, intraoperative, and postoperative data can assist in monitoring recovery and predicting complications. After discharge, postoperative data obtained from personal devices can continue to integrate with data obtained from hospital stays to maximize weight loss and optimize the resolution of obesity-related comorbidities.

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There are numerous advantages to using AI-assisted robotic technology in surgeries. AI systems that analyze the patient's information before surgery facilitate the work of surgeons during surgical procedures. Due to their high precision, flexibility, and 360-degree range of motion, these robots can intervene in areas that are difficult for human hands to reach (STM ThinkTech, 2019). Moreover, they prevent errors in doctors, such as hand tremors, that may occur due to fatigue during prolonged surgical operations. Compared to traditional surgery, the surgical intervention can be performed with only a small incision on the patient. The likelihood of complications for the patient is lower than in normal surgery. The level of pain endured by the patient is lower than that of traditional surgery.

Consequently, patients can recover more quickly and return to their social lives. Studies show that AI-assisted robotic surgeries reduce the duration of inpatient treatment by 21% and complications during surgery by five times compared to traditional methods. This significantly reduces hospital care and treatment expenses. In the United States, this has resulted in USD 40 billion savings in the healthcare system (Marr, 2018).

The development of AI technology enables surgeons to visualize the necessary information about the patient during surgery instantly. For example, AI-assisted robots allow surgeons to take ultrasounds during surgeries, providing real-time information about the tumor's condition (STM ThinkTech, 2019).

In recent years, significant developments have been observed in tele-robotic[2] surgery systems that enable remote surgical procedures. Initially developed by NATO for use in war zones, telerobotic surgery has become more widespread over time. In 2001, Dr. Jacques Marescaux performed laparoscopic cholecystectomy surgery on a patient in Strasbourg while physically present in New York through telesurgery (Ghezzi & Corleta, 2016).

Artificial intelligence is instrumental in increasing the accessibility of health services for people in regions with poor social and economic conditions, where health services are inadequate, and the number of doctors and surgeons is less than the number of patients. In this way, everyone can benefit from AI-based health systems. However, it has been

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[2] In the most general definition, tele-robotic surgery is the completion of the operation by remotely transferring audio, video and health data about the patient without the surgeon being physically present at the patient's side and in the operating room.

observed that robotic surgical systems that offer teleoperation opportunities may be exposed to cyber security vulnerabilities and denial-of-service attacks, and there is a need to improve them in order to eliminate the cyber security vulnerability.

Despite the numerous advantages of AI-assisted robots, there are also potential disadvantages that could hinder their usage. Firstly, the parts of these robots are expensive in case of malfunction, leading to high repair costs (Rai, 2013). It is thought that as the demand for the use of these robots in surgeries increases, their prices and maintenance costs may decrease over time.

The significance of accurate diagnosis for initiating proper treatment cannot be denied. AI technology assists pathologists in diagnosing diseases, enabling the determination of personalized and accurate treatment methods. Studies have shown that algorithms achieve better results than human pathologists in diagnosing diseases (Liu, et al., 2021, p. 1106). By utilizing extensive databases, AI scans symptoms worldwide, aiding doctors in making informed decisions about the treatment process. This allows doctors to determine personalized treatments (STM ThinkTech, 2019).

IBM's AI system, Watson, has also achieved considerable success in the treatment domain. In a study conducted at a Cancer Center serving 200,000 cancer patients in India, Watson's diagnostic results for breast cancer cases were found to align with the diagnoses made by the cancer board by 90% (Uçar, 2018). Moreover, there was an 85% concordance observed between the treatment recommendations applied by oncologists for breast cancer patients, and the suggestions of the AI system called "Watson for Oncology" (Somashekhar, C., & Patil, 2016). In the United States, the ratio of cancer patients to oncologists is 1:100, whereas in India, it is 1:1600 (Uçar, 2018). In this context, AI technology is a highly functional solution to address this significant imbalance.

To achieve optimal results from treatment, it is crucial for patients to receive the correct medication in the proper dosage. AI technology contributes to patient-focused management processes by offering personalized services in the field of personalized drug therapy (Akalın & Veranyurt, 2020). For example, artificial intelligence technology is used in the treatment of cancer, one of the most challenging diseases of today, to make special drug combinations for patients by analyzing the biopsy results of patients in the field of oncology (Gerke, Babic, Evgeniou, & Cohen, 2020).

Waste and incorrect prescription of medicines causes a huge cost. Almost 2.9 trillion dollars are wasted every year in OECD countries due to the unnecessary use of prescribed antibiotics (OECD, 2015). It is known that discarded medicines cause financial losses worth millions of dollars every year in the USA.

There are artificial intelligence-based mobile phone applications to monitor whether patients take their medications instantly and to intervene immediately in any unexpected situation (STM ThinkTech, 2019). A smartphone application called AiCure monitors patients' medication use, helps them take their medications on time, and determines whether they are taking the correct medication (Comstock, 2016).

Another smartphone application developed to support patients in this field is the Abilify MyCite app. Timely and regular intake of medication is crucial in the treatment of manic and bipolar disorders, as well as schizophrenia. The Abilify MyCite application allows patients to track their medication intake times through the screen, aiming to enhance medication adherence during acute treatment (Yeasmin, 2019). Such an application is highly significant, as schizophrenic patients who fail to take their medications on time require more hospitalization and intensive care treatment due to psychotic episodes (Holley & Becker, 2021).

With the global increase in life expectancy, the elderly population is also growing. As people age, various diseases accompany the aging process, often requiring elderly individuals to depend on others. Robots equipped with artificial intelligence technology offer significant solutions to eliminate this dependency. AI robots enable the elderly to live longer independently and minimize the need for hospitalization. They ensure timely medication intake, provide information to relatives and healthcare institutions in emergencies, and support individuals in their walks by providing physical support (STM ThinkTech, 2019). The number of these robots is increasing day by day.

In summary, artificial intelligence technology assists healthcare professionals in providing personalized treatment options to patients. It offers appropriate solution recommendations and streamlines the diagnostic and treatment process by minimizing or eliminating human intervention in processes that require both time and effort (Kaur, Garg, & Gupta, 2021). By shortening the diagnosis period, AI technology accelerates the decision-making process, positively impacting treatment planning. It minimizes resource consumption in the healthcare sector, thereby reducing treatment costs.

3.2.6. Drug Development

Medicine holds great importance for humanity, playing a crucial role in treating and preventing diseases, improving quality of life, and extending the human lifespan. However, the process of developing drugs, which are of such great significance to humanity, is lengthy and complex. The successful completion of the discovery process, clinical trials, and marketing stages is required to make drugs readily available. This process encompasses high costs, uncertainties, and failures. Studies indicate that the process of discovering and reaching people with drugs using traditional methods spans 10-15 years, with an average success rate of only 2.01% (Cüvitoğlu & Işık, 2020). This success rate is notably low.

In the present day, the average cost incurred for the development of a drug is approximately $2.87 billion. The global budget allocated to pharmaceutical research and development is around USD 140 billion (Pfizer, n.d.). Even a small mistake during this process can jeopardize the reliability of the entire procedure. Artificial intelligence (AI) technology facilitates the discovery, production, and broader accessibility of drugs at lower costs and in a safer manner. AI contributes significantly to the healthcare sector by saving time spent on the development of new drugs and reducing the cost of clinical trials (Ali, et al., 2023).

The first drug developed using AI technology was created through collaboration between the British company Exscientia and the Japanese pharmaceutical company Sumitomo Dainippon Pharma for the treatment of obsessive-compulsive disorder (Wakefield, 2020). The clinical trial phase, which was expected to take years using traditional methods, was completed in just 12 months thanks to AI technology, resulting in significant time savings.

AI technology, specifically the IBM-developed system named Watson, contributes to new drug research studies by scanning literature (Uçar, 2018). Watson accelerates the drug discovery process, as exemplified by Pfizer, one of the world's largest pharmaceutical companies, which utilizes Watson, a machine learning-based system, to aid in discovering immuno-oncology treatments (Agrawal, 2018).

In healthcare services, AI technology has assisted drug companies in expediting the drug discovery process. Atomwise, a biotechnology company specializing in artificial intelligence-based drug design and drug discovery, developed a drug proposal against the Ebola virus, transmitted from person to person and has high lethality, by processing billions of data in 2016 (Atomwise, n.d.). Abrahan Heifets, CEO of Atomwise, mentioned that the accelerated drug development process, thanks to artificial intelligence technology, can be applied to other diseases such as bird flu, measles, and drug-resistant tuberculosis, providing significant benefits for humanity in a very rapid and advantageous way (Atomwise, n.d.).

An average of 7000 rare diseases are known worldwide (Stephens & Blazynski, 2014, p. 781). Patients with rare diseases, which take an average of five years to be diagnosed, are frequently hospitalized and are exposed to long-term complications because treatments do not respond appropriately (Hurvitz, Azmanov, Kesler, & Ilan, 2021). More than 350 million people worldwide are affected by these challenges in diagnosing and treating rare diseases. This situation creates a tremendous economic burden on the healthcare system and causes patients to lose their lives (Faviez, et al., 2020). Artificial intelligence technology is used to discover drugs for rare diseases that have yet to be studied due to the high cost and risk of drug discovery. Artificial intelligence technology ensures less cost and time spent in drug discovery for rare diseases (Wojtara, Rana, Rahman, Khanna, & Singh, 2023).

As can be seen, artificial intelligence technology accelerates the process of developing medicines that save people's lives. Thanks to artificial intelligence technology, the costs of finding and developing new drugs have been reduced by 70%. In other words, it saves billions of dollars that can be invested in maintaining health ecosystems (Jena, 2022).

CHAPTER 4

EXAMINING THE USE OF ARTIFICIAL INTELLIGENCE IN THE HEALTH SYSTEM IN ITS ECONOMIC DIMENSION

In this study, firstly, research data terms related to the subject have been provided, and artificial intelligence studies in the field of healthcare have been examined. Definitions of artificial intelligence, its historical background, and data regarding its administrative and clinical applications in the healthcare domain were explored. Subsequently, the economic impacts of the use of artificial intelligence technology in the field of healthcare have been investigated. During these investigations, reviews and compilations were conducted from various journals and books, utilizing data from sites such as Pubmed, Google Scholar, ProQuest, Web of Science, Scopus, Science Direct, EMBASE, and Dergipark.

The influence of artificial intelligence technology on the economy is increasing day by day; this technology is transforming the economy along with many sectors in the real economy. The rapid development of this technology is transforming employment and the financial services industry along with several sectors in the real economy. In its report titled "Sizing the prize: What is the real value of AI for your business and how can you capitalize?" PwC has outlined the potential contribution of artificial intelligence to the global GDP and the sectors with the highest potential (PwC, 2017). In this context, artificial intelligence is expected to affect the health, automotive, and financial services sector the most. PwC has created an "AI Impact Index" to compare the present and 2030 in terms of the economic potential of solutions presented by artificial intelligence companies by examining regional economies and eight commercial sectors worldwide (PwC, 2017). According to this index, the potential contribution of artificial intelligence to the global economy in 2030 will be up to $15.7 trillion. It is noteworthy that this estimated impact is greater than the current production of China and India combined. It is expected that $9.1 trillion of this contribution will be due to consumption side effects, and $6.6 trillion will be due to the increased efficiency resulting from artificial intelligence technology. Another study by Bughin et al. also predicts that artificial intelligence will contribute $13 trillion to the global economy by 2030 and increase countries' economies by 16% (Bughin, Seong, Manyika, Chui, & Joshi, 2018).

Artificial intelligence (AI) technology is also affecting professions and, consequently, employment. By 2030, it is estimated that 326 million jobs will be impacted by AI technology (PwC, 2017). While AI may lead to the elimination of certain occupations, it will also create new job opportunities. For instance, as autonomous vehicles become more widespread over time, there is a projected need for autonomous vehicle controllers similar to air traffic controllers. Same-day delivery, robotic packaging, and storage will require more work for both robots and humans. All these developments facilitated by AI are expected to lead to the emergence of new job sectors that do not exist today. On the other hand, unskilled jobs are expected to diminish with the increasing use of AI technology.

In the same report of PwC, it is anticipated that the economic impacts of AI worldwide will vary from region to region. For example, China (Total impact: 26.1% of GDP) and North America (Total impact: 14.5% of GDP) are expected to be most economically affected by AI. Developing countries are projected to experience lower increases compared to these countries due to lower adoption and implementation rates of expected AI technologies (PwC, 2017, p. 1).

Another indicator of the magnitude of the current state of the AI economy is the annual average increase of AI-related patents worldwide, which has grown by approximately 6% between 2010 and 2015. This growth rate is considerably higher than the annual growth rate calculated for patents in other fields. Approximately two-thirds of patent applications related to AI are filed by Japan, South Korea, and the United States (OECD, 2017). Research conducted in China in 2019 revealed that by the end of 2018, around 15,916 AI startups worldwide had received approximately $78 billion in investments (Shang, 2019, p. 1).

In a study covering 12 advanced economies that contribute more than 0.5% of global economic output, it is predicted that by 2035, AI technology will double annual global economic growth rates due to increased workforce productivity, time savings, and the creation of new income streams (Accenture). It is expected that by 2030, approximately 70% of companies will use at least one type of AI technology. Another research study, in addition to the aforementioned report, has presented similar findings regarding the contributions of AI technology to the global economy. McKinsey estimates that by 2030, AI could increase global GDP by approximately 1.2% annually, providing an additional economic output of around $13 trillion (Bughin, Seong, Manyika, Chui, & Joshi, 2018).

Artificial intelligence (AI) technology has a broad range of applications in the field of healthcare. The rapid and widespread development of digital health technology, including AI technology, in the healthcare sector today is undeniable. The importance of digitization in healthcare systems is increasing daily to address cost pressures, decreasing efficiency, workforce challenges, the growing proportion of the aging population worldwide, and the rise in chronic diseases. Additionally, the globally impactful COVID-19 pandemic has put considerable strain on healthcare systems, accelerating digitalization efforts in the health sector. The increase in the number of patients has led to a surge in demand for healthcare services, revealing inadequacies in workforce numbers and challenges in the supply chain. In response to these challenges, healthcare service providers have turned to technology to alleviate the issues faced in the healthcare system.

The healthcare sector, with an annual revenue exceeding 12 trillion dollars and over 60 million healthcare workers, is one of the world's largest industries (World Economic Forum, 2023, p. 6). According to both OECD and United Nations reports the economic size of the healthcare sector continues to grow rapidly (OECD, 2018). The sustainability of health and social security systems is of utmost importance.

Looking at the above-mentioned OECD data in 2022, the country with the highest healthcare spending per capita is the United States, with $12.550 USD per person. Switzerland follows closely in second place with $ 8.049 USD per person, and Germany, with a tiny difference, ranks third with $ 8.011 USD per person. Following these countries are Norway, Austria, and the Netherlands, respectively.

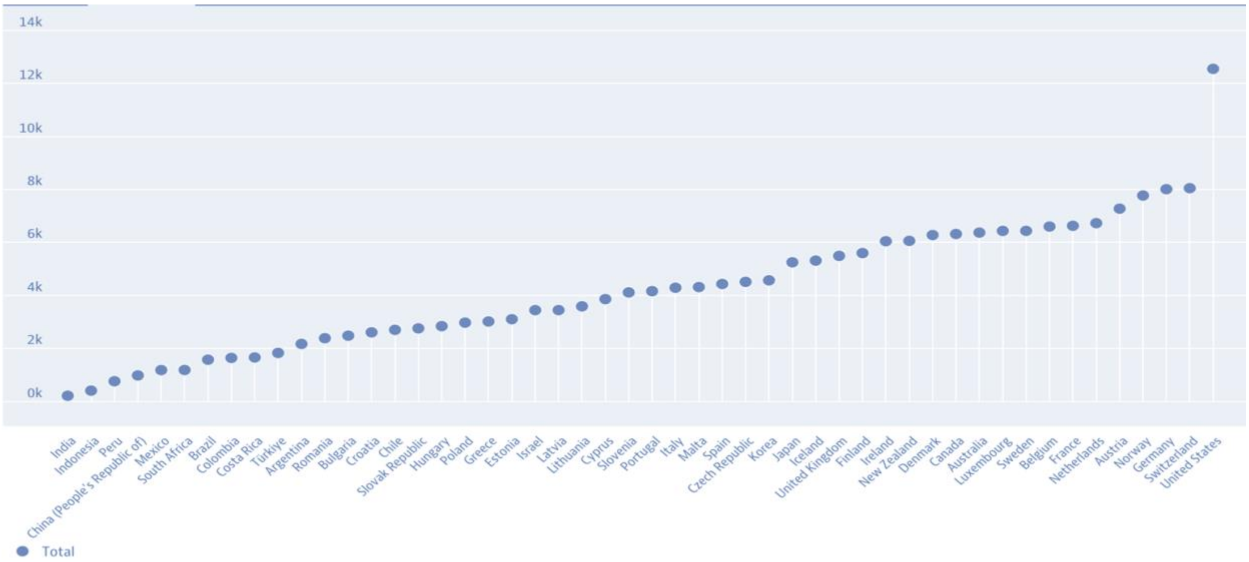

Figure 17:*Country Healthcare Spending in 2022*

Source: *OECD (https://data.oecd.org/healthres/health-spending.htm)*

Healthcare expenditures in all countries show a more significant increase than the countries' economic growth rates. Therefore, the share of healthcare expenditures in the overall economy has been steadily increasing since the 1980s. The financing of healthcare expenditures, predominantly consisting of pharmaceuticals, medical devices, and healthcare personnel salaries, is covered mainly by public funds in most OECD countries. In 2021, an average of 73% of healthcare expenditures in OECD countries was financed by public sources.

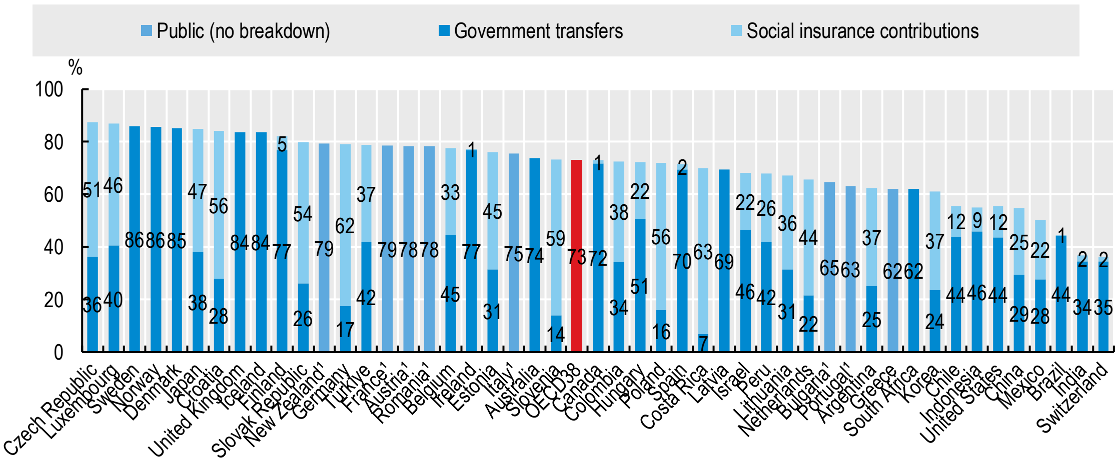

Figure 18:*Country Healthcare Spending Growth Rate*

When examining the percentage of countries' healthcare expenditures in their Gross Domestic Product (GDP), it is observed that healthcare expenditures increased from 6.2% to 16.6% of GDP between 1970 and 2022 in the United States. Currently, after the United States, Germany (12.7%), France (12.1%), and Japan (11.5%) have the highest healthcare expenditure-to-GDP ratios. As the table below shows, in 2022, 16 high-income countries spent more than 10% of their GDP on healthcare. The majority of OECD countries allocate more than 9.2% of their GDP to healthcare.

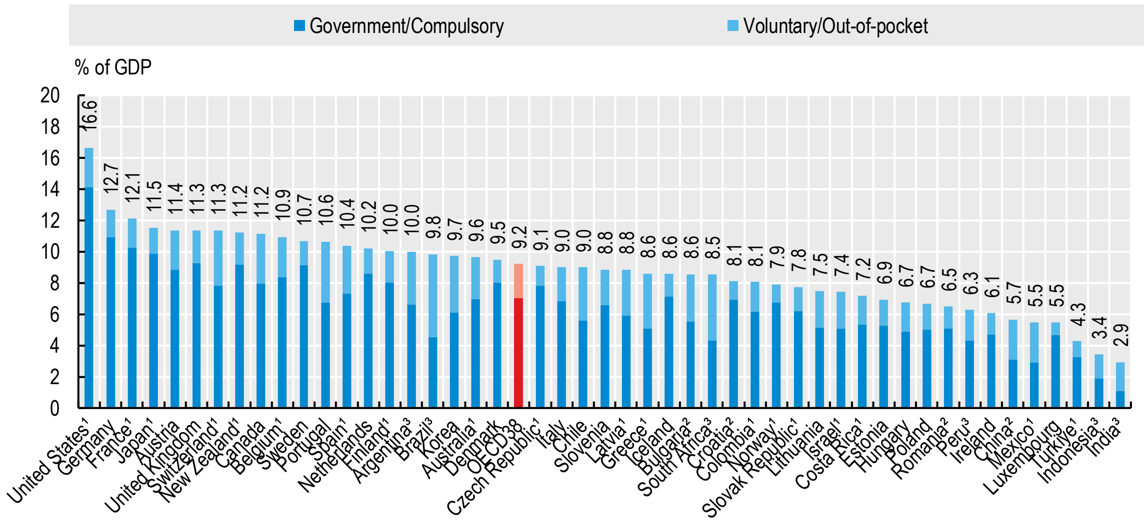

***Figure 19**:Country Healthcare Spending/GDP*

***Source:** OECD (https://data.oecd.org/healthres/health-spending.htm)*

In recent years, the cost of healthcare services has indisputably been on an unsustainable upward trend. Due to the cost pressure in healthcare services, there is a noticeable decrease in the share of the public budget allocated to health. According to the World Health Organization's "Public Spending on Health: A Closer Look at Global Trends" report, in low-income countries, the share of the public budget allocated to health decreased from 7% to 5% in 2016 (WHO, 2018). The rate of increase in the share of health in the country budget in middle and high-income countries has followed a horizontal trajectory since 2012 (STM ThinkTech, 2019). Before the COVID-19 pandemic, on average, OECD countries were spending approximately 8.8% of their GDP on healthcare. This ratio increased to 9.7% in 2021 but dropped to 9.2% in 2022 due to the unprecedented challenges posed by the global COVID-19 pandemic. Despite many OECD countries increasing public resources for healthcare services post-pandemic, the current economic and geopolitical outlook, rising energy prices, bottlenecks in supply chains, increased freight costs, workforce shortages, and the Russia-Ukraine war in 2022 have introduced new challenges to costs, along with inflationary pressures. As a result of these economic and geopolitical developments, healthcare costs have also been affected (OECD, 2023). By the end of 2023, total healthcare expenditures (public and private sector combined) are expected to increase by 4.9% in nominal USD due to rising costs and wages. However, it is anticipated that expenditures will decrease in real terms due to an inability to keep up with inflation (EIU, 2023).

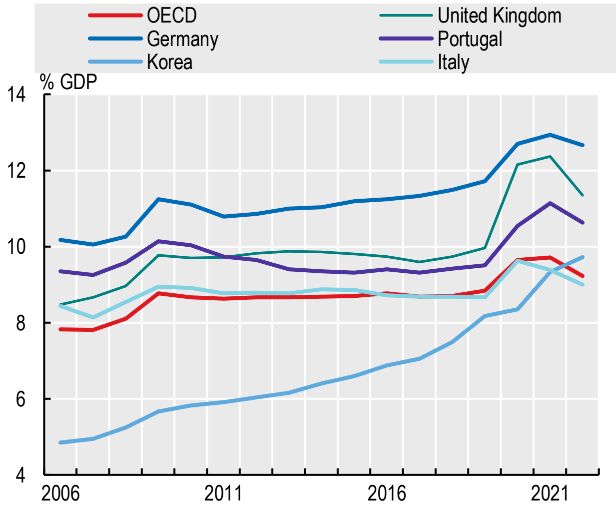

Figure 20:*Health Expenditure as A Share Of GDP, Selected Countries, 2006-22*

Furthermore, studies indicate that a significant portion of public budget expenditures on healthcare are wasteful. For instance, a study conducted by healthcare experts in the Journal of the American Medical Association reveals that a quarter of healthcare spending in the United States is wasted (Shrank, 2019). Administrative complexity, misdiagnosis and treatment, overtreatment, inappropriate healthcare delivery, lack of coordination, operational waste, incorrect use of medical materials, and pricing failures contribute to an estimated waste of $760 billion to $935 billion annually in the U.S. healthcare system. Inefficiencies and waste in healthcare spending contribute to costs in the healthcare sector. As governments cover most healthcare expenditures, reducing wasteful spending and inefficiencies would contribute to reducing countries' debts. Therefore, reducing such a significant expenditure category in countries' GDPs is crucial for their economies.

Digitalization and artificial intelligence technology in the field of healthcare have a crucial place in eliminating many problems that arise in the healthcare system, increasing the quality and efficiency of healthcare services, and ensuring effectiveness (Jiang, et al., 2017).

As previously mentioned in the preceding sections, artificial intelligence (AI) technology is actively utilized in the field of healthcare, both in clinical areas such as diagnosis, treatment, drug discovery, elderly care, early intervention and in administrative areas such as patient management and effective utilization of hospital capacity. The use and effectiveness of AI technology in healthcare are increasing day by day, contributing to the enhancement of efficiency and reduction of costs. This positively impacts both individual patients and national economies.

While the use of AI technology in administrative areas may be less revolutionary compared to its clinical applications, it holds significant potential for providing efficiencies. Expenses related to administrative activities in healthcare services annually contribute to the increase of total healthcare costs by billions of dollars. According to research, 34% of healthcare expenditures in the United States are attributed to administrative costs (Himmelstein D. U., 2020). Administrative applications are not only costly but also consume a significant amount of time for healthcare professionals. Nurses spend 51% of their working hours, and doctors spend 16% of their working hours on bureaucratic tasks unrelated to patient treatment, such as preparing patient records, writing prescriptions, and issuing instructions for laboratory tests (STM ThinkTech, 2019). AI technology causes highly effective results in general health management, documentation management, and the efficient use of healthcare institutions' capacity.

Through AI-based ambulance dispatch systems, ambulance response times are standardized, real-time data is analyzed for traffic congestion, enabling time and cost savings, and reducing mortality rates due to early intervention is possible.

AI technology is also utilized to deliver limited healthcare services to patients in hospitals efficiently. In a hospital in Singapore, machine learning models were employed to predict the probability of re-hospitalization within 30 days for discharged patients. This method resulted in saving 3,200 bed day annually. The 30-day hospital readmission rate decreased from 11.7% in 2017 to 10.1% in 2019 (Wu C. X., 2021).

The emergence of pandemics such as SARS, Ebola, and, most recently, COVID-19 has underscored the critical importance of proper supply chain management in the field of healthcare (Araz, Choi, Olson, & Salman, 2020). In hospitals located in the United States, over $25 billion is spent annually on unnecessary supply chain costs. Artificial intelligence (AI) technology is also employed to improve supply chains in healthcare services. Through machine learning models, predicting how many patients with certain complaints will visit a hospital and enabling better inventory planning is possible. Improved inventory management is expected to result in less waste and cost savings (Ayyıldız, 2021).

AI-based chatbots are utilized to answer patients' questions and provide information. Technologies like Natural Language Processing (NLP) allow patients to inquire about doctor appointments, invoice payments, and other matters, facilitating question-and-answer interactions. This enables medical professionals to allocate more time to other crucial tasks. AI-based chatbots designed to support doctors in administrative tasks are expected to save doctors up to 499.8 million hours, potentially resulting in savings of €27.3 million (Deloitte, 2017).

Cases of irregularities in healthcare occur worldwide with varying intensities and types. Although it is challenging to precisely determine their share in total healthcare expenditure, globally, these irregularities constitute 10% of total healthcare expenditures (Thaifur, Maidin, Sidin, & Razak, 2021). AI technology also addresses fraudulent activities and irregularities in healthcare. AI-supported data mining techniques that detect abnormal situations in health insurance and insurance claims are anticipated to save $17 billion annually in the United States (Kalis, Collier, & Fue, 2018).

Findings from the 2023 Global Health Care Outlook report indicate that 42% of doctors feel exhausted. Moreover, the global healthcare sector is expected to experience a shortage of 12.1 million skilled personnel by 2035 (Deloitte, 2023). Therefore, any innovation that saves time for healthcare personnel is crucial. AI technology has the potential to expedite administrative operations in healthcare by reducing costs, automating data entry, eliminating situations arising from human errors, and automatically processing Electronic Health Records (EHR) (Healthdatasharing). These outcomes directly allow doctors and nurses to dedicate more time to patient care, leading to workforce savings.

A study published in the Harvard Business Review in 2018 suggests that the adoption of AI-supported systems for tasks such as creating patient records and prescribing medications in the United States could result in annual savings of $18 billion in healthcare expenditures (Kalis, Collier, & Fue, 2018).

Artificial intelligence makes significant contributions to all clinical processes in the field of healthcare, more so than in administrative processes. It plays a vital role in disease prevention, diagnosis/treatment processes, and post-treatment care processes.

The contribution of AI in preventive healthcare is invaluable. The increasing number of AI-based mobile health applications provide personalized health recommendations by monitoring individuals' health data and activities. The global Mobile Health (mHealth) application market exceeded $28 billion in 2018, with an expected market size of $102 billion by the end of this year (Mobile Health (mHealth) App Market, 2023). These applications facilitate the collection and processing of both individual and mass health data. Collecting and analyzing mass health data to identify potential general health issues for preventive measures are anticipated to reduce the burden on healthcare systems and enhance overall well-being. The most significant contribution of AI in preventive healthcare is expected to be reducing the cost of public health management (STM ThinkTech, 2019). The ability to intervene early in pandemic situations is expected to result in significant savings in administrative and treatment expenses for institutions (Dickson, 2018).

Wearable devices enable the early detection of cardiovascular diseases, hypertension, diabetes, and obesity (Majumder, Mondal, & Deen, 2017). By detecting crucial indicators of heart failure in advance, smartwatches are expected to significantly reduce hospitalizations, resulting in savings of up to €36.9 billion (Deloitte, 2020). Also, using smart wristbands, nurses can remotely monitor their patients, receiving notifications in case of deterioration. This is estimated to lead to savings of €6.1 billion (Deloitte, 2020).

In an analysis investigating the economic impact of AI in medicine, researchers presented an economic model for AI-supported diagnosis and treatment. The model selected 20 hospitals and, for each hospital, a cohort of 20 patients for one year. The analysis predicted cost savings over ten years.

According to the results obtained from the study, AI-enabled diagnosis is expected to save 3.33 hours per day in the first year and 15.17 hours per day over ten years. Cost savings are calculated as $1,666.66 per day per hospital in the first year and $17,881 per day per hospital in the tenth year.

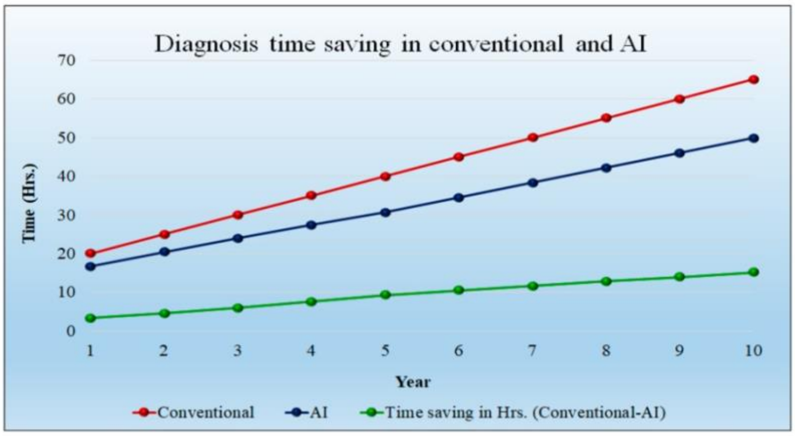

Figure 21*:Diagnosis Time Saving in Conventional and AI*

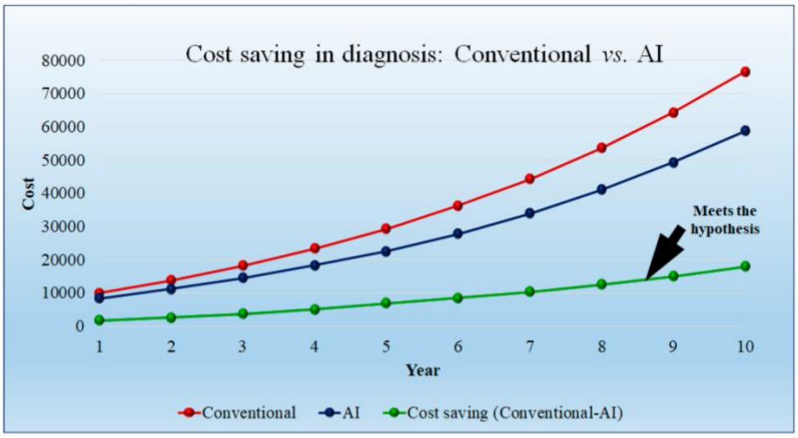

Figure 22:*Cost Saving in Diagnosis: Conventional vs AI*

It has been concluded that thanks to artificial intelligence, 21.67 hours per day per hospital will be saved in the treatment processes in the first year, and 122.83 hours per day per hospital will be saved in the 10th year. Cost savings are predicted to be 21,666.67 USD per day per hospital in the first year and 289,634.83 USD per day per hospital in the 10^{th} year.

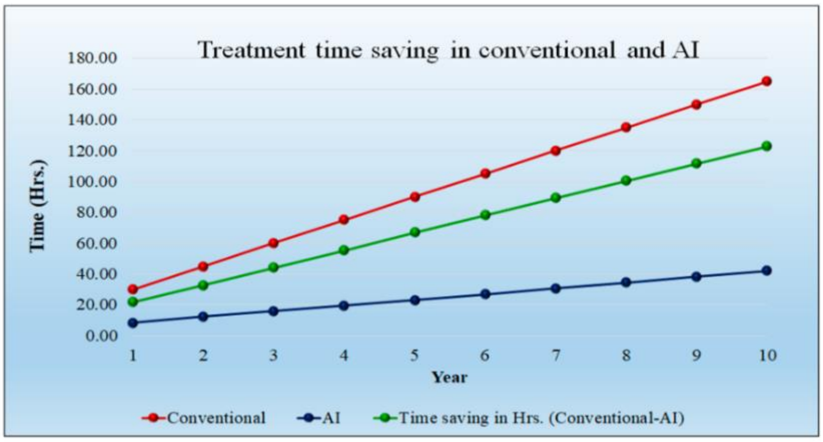

Figure 23:*Treatment Time Saving in Conventional and AI*

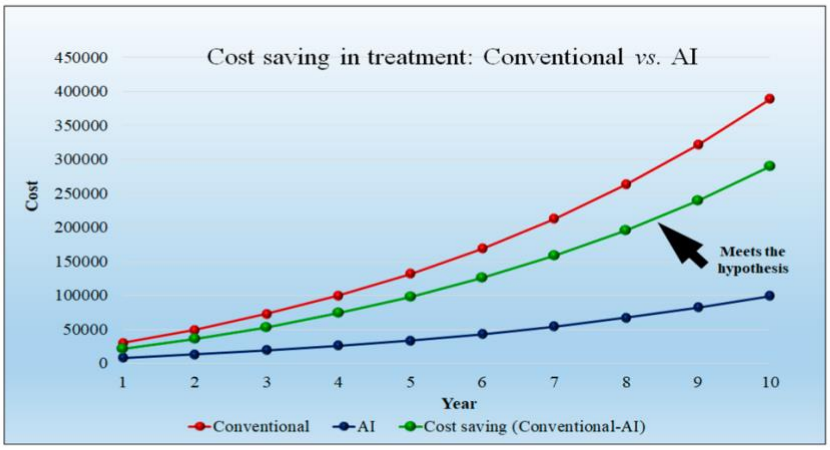

Figure 24*:Cost Saving in Treatment: Conventional and AI*

The study indicates that the implementation of artificial intelligence (AI) in diagnosis and treatment leads to time savings, subsequently reducing healthcare costs (Khanna, 2022). AI shortens the duration of both diagnosis and treatment compared to traditional methods, achieving high accuracy in a short period. Time savings in diagnosis and treatment directly translate into cost savings in healthcare. Therefore, AI, when compared to conventional methods, reduces healthcare costs. Another finding from the study is that the application of AI technology in the healthcare sector will help companies maximize their return on investment and simultaneously reduce costs (Khanna, 2022).

A research study examining the integration of AI and telemedicine in ophthalmology found that combining these technologies could result in cost savings of $1.1 million (Ramessur, et al., 2021).

In Europe, the application of AI is expected to contribute to the prevention, diagnosis, and treatment improvement of childhood obesity, dementia, and breast cancer, resulting in healthcare systems saving over $196 billion.

As the global population ages, there is a significant increase in the number of Alzheimer's patients. An advanced learning algorithm developed for early diagnosis of Alzheimer's disease led to diagnoses approximately 75 months earlier than traditional methods (Ding Y. S., 2019). Early diagnosis saved $7 trillion (Alzheimer's Association, 2018).

One of the areas where artificial intelligence demonstrates the highest success in healthcare is the evaluation of images in radiology. Numerous studies have proven that the performance of AI in radiology image interpretation surpasses that of physicians (Tekla, 2017). American radiologists need to interpret radiological images every two seconds, but the number of images a human can review is limited (Uçar, 2018). Due to the incorrect interpretation of images by healthcare professionals, 90 million patients receive misdiagnoses (STM ThinkTech, 2019). AI-based applications can perform millions of screenings with high accuracy in a short period. An AI-based radiological imaging application developed in the United States saves nearly $3 billion in the healthcare system annually. Similar results have been observed in a European study, indicating a potential annual savings of €7.4 billion through AI in this field (Deloitte, 2023).

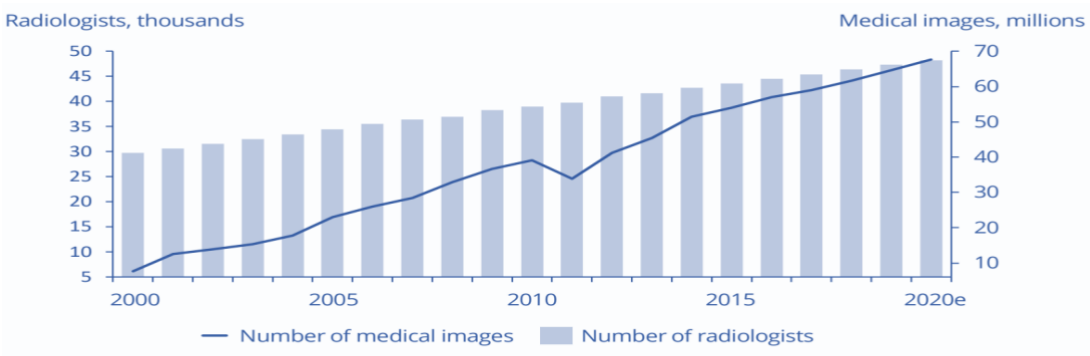

Figure 25:*62% more radiologists vs. 792% more medical images: PET, MRI, CT (EU 2000-2020)*

The utilization of artificial intelligence (AI)-assisted robotic technology in surgeries presents numerous advantages. AI-supported robotic surgeries reduce the duration of in-hospital treatment (length of stay) by 21%, and complications during surgery are reduced by five times. This significantly diminishes the expenses associated with patient care and treatment, resulting in substantial cost savings for healthcare. This has led to a savings of $40 billion in the U.S. healthcare system (Marr, 2018).

A study conducted in 2022 by an insurance company found that digital health technology reduced emergency room utilization by 9% and hospital admissions by 17%, resulting in a savings of $641 per member per month (Goldsmith, 2022).

The wastage and improper prescription of medications incur significant costs. The unnecessary prescription of antibiotics has led to $2.9 trillion in waste across OECD countries (Cecchini, Langer, & Slawomirski, 2015). They are discarding unused medications in the U.S., resulting in a cost loss of millions of dollars annually. AI technology contributes to personalized medication services, enhancing patient-focused healthcare management processes and preventing wastage (Akalın & Veranyurt, Sağlıkta Dijitalleşme ve Yapay Zeka, 2020).

The process of developing drugs is lengthy, complex, and costly, causing a shortage of drugs worldwide. The PGEU Medicine Shortages Survey 2021 results confirm antibiotic shortages in Europe (PGEU GPUE, 2022). AI technology accelerates the drug development process, reducing costs by 70% for discovering and developing new drugs. This translates into billions of dollars in potential savings that can be invested in sustaining healthcare ecosystems (Jena, 2022).

A report by Deloitte in 2020 titled "The Socio-Economic Impact of AI In Healthcare" evaluates the socio-economic impact of AI technology usage in healthcare within European healthcare systems.

The European healthcare system faces challenges such as a shortage of critical medical professionals, long waiting times, increased service demand due to an aging population, and financial constraints. AI technology can alleviate some of these constraints by reducing the time healthcare workers spend on repetitive tasks, allowing them to focus on high-value activities, such as spending more time with patients or seeing more patients. Its ability to quickly process large amounts of data supports faster and more accurate diagnostic and treatment decisions. Moreover, the role of AI technology in enabling patient-centered prevention and care has led to significant improvements in access to care, quality, and health outcomes.

Artificial Intelligence Technology;

Thanks to Wearable Devices, annually:

- 298,000 – 313,000 lives could be saved
- Savings of 46.6-50.6 billion Euros (including opportunity costs)
- 301.6-336.1 million hours saved

Per year, thanks to views:

- 36,000 – 41,000 lives could be saved
- Savings of 16.1-18.6 billion Euros (including opportunity costs)
- 15.1-32.7 million hours saved

Thanks to laboratories, annually:

- Savings of 834.4-883.5 billion Euros (including opportunity costs)
- 50.4-53.4 million hours saved

Thanks to Physiological Monitoring, annually:

- 39,000 – 42,000 lives could be saved
- Savings of 43.6-45.7 billion Euros (including opportunity costs)
- 323.8-375.4 million hours saved

Thanks to Big Data Analysis:

- Savings of 14.0-38.0 billion Euros (including opportunity costs)

Thanks to Virtual Health Assistance, annually:

- Savings of 32.0-36.8 billion Euros (including opportunity costs)
- 961.1-1,154.0 million hours saved

Thanks to Personalized Applications, annually:

- 6,000 – 7,000 lives could be saved
- Savings of 1.5-1.6 billion Euros (including opportunity costs)

Thanks to robotics, per year:

- Savings of 16.4-20.4 billion Euros (including opportunity costs)
- 330.8-367.5 million hours saved

The anticipated active utilization of artificial intelligence (AI) technology in the healthcare sector is expected to result in saving between 380,000 and 403,000 lives annually, along with cost savings ranging from €170.9 billion to €214.4 billion and time savings between 1,659 million and 1,944 million hours.

According to a study by Accenture, clinical AI applications in healthcare have the potential to save $150 billion for the U.S. healthcare economy by 2026. The anticipated potential gains from AI, covering robotic-assisted surgery ($40 billion), virtual nurse assistants ($20 billion), administrative support ($18 billion), fraud detection ($17 billion), dosage error reduction ($16 billion), connected devices ($14 billion), clinical trials ($13 billion), early diagnosis ($5 billion), automatic image diagnosis ($3 billion), and cybersecurity ($2 billion), are expected to result in a total net saving of $150 billion (Accenture, 2020).

AI has the potential to alleviate the burden on clinicians and enable employees to perform their jobs more effectively. Consequently, the analysis predicts that AI will address the increasing workforce gap in healthcare services.

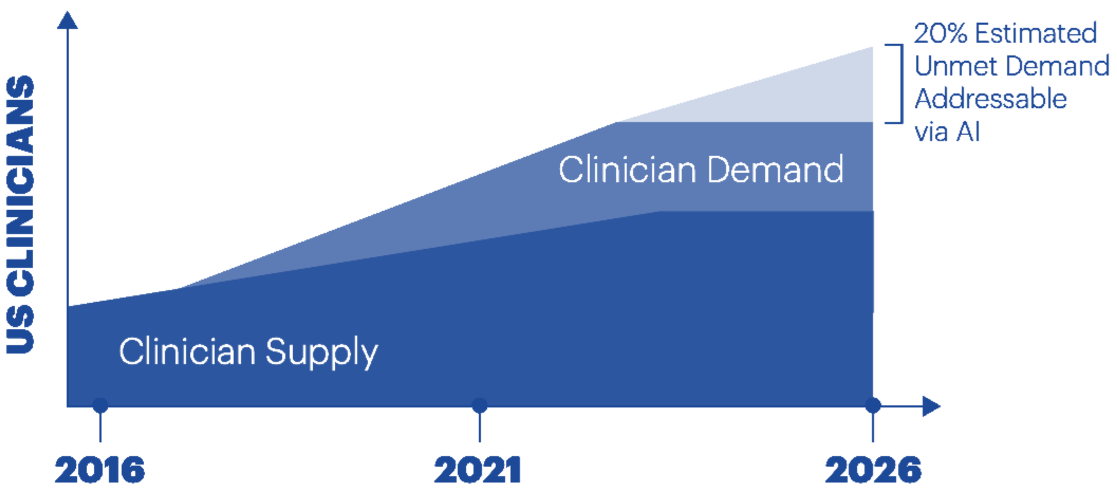

Figure 26:*US Clinician Demand and Supply Curve*

A research study conducted by McKinsey and Harvard, examining the potential impact of AI on healthcare expenditures, estimates that implementing AI in healthcare could save up to $360 billion annually for the United States.

The report, which includes the findings of the study, focuses on three stakeholders in the healthcare system: hospitals, physicians, and private payers. AI technology finds applications in the healthcare system's clinical and administrative processes. Administrative costs are estimated to constitute 25% of all U.S. healthcare expenditures (Sahni, Stein, Zemmel, & Cutler, 2023). Most of the hospital savings come from use cases improving clinical operations, such as operating room optimization. Operating rooms are critical areas in hospitals, and efficient surgeries lead to wasted hours, excessive space usage, improved patient access, and worsened patient experience. Active usage of AI technology in this area increases the capacity of operating rooms, saves time for healthcare personnel, and optimizes the supply chain, resulting in significant cost savings (Kılıç , et al., 2020). AI technology-based virtual health assistants answer basic questions that patients frequently seek, saving time for healthcare workers and relieving patients from the need to visit the hospital each time. AI technology predicts which patients pose a higher risk for readmission, enabling doctors to intervene early.

As a result of the active use of AI technology in healthcare:

- Private payers are expected to save an average of 7% to 9%, i.e., between $80 billion and $110 billion annually over the next five years,
- Physician groups are expected to save an average of 3% to 8%, i.e., between $20 billion and $60 billion annually,
- Hospitals are expected to save an average of 4% to 11%, i.e., between $60 billion and $120 billion annually.

In summary, the report forecasts that the active use of AI technology in clinical and administrative processes in healthcare will reduce overall healthcare expenditures by 5% to 10%.

The research excluded expenses such as maintenance costs for artificial intelligence (AI) technology to determine the net savings. Consequently, it is estimated that within the next five years, annual net savings of $200 billion to USD 360 billion can be achieved in healthcare services through the use of AI technology without compromising the current quality and accessibility of healthcare services. In addition to this savings amount, non-financial benefits such as improved healthcare service quality, increased access to healthcare services, enhanced patient experience, and increased satisfaction of healthcare personnel are also expected to be realized.

Stakeholder group	Total costs (2019), $ billions	Net savings opportunity (2019), $ billions	Net savings opportunity as percent of stakeholder group's total costs	Percent of net savings opportunity focused on administrative costs
Hospitals	$1,096	$60–$120	5–11%	~40%
Physician groups	$711	$20–$60	3–8%	~50%
Private payers	$1,135	$80–$110	7–10%	~20%
Public payers	$511	$30–$40	5–7%	~20%
Other sites of care	$817	$10–$30	1–4%	~50%
Total		**$200–$360**	**5–10%[1]**	**~35%**

1. This represents the percent of total national health spending in 2019.

Source: National Health Expenditures data; authors' analysis

Figure 27:*Breakdown of Overall AI Net Savings Opportunity Within Next Five Years Using Today's Technology Without Sacrificing Quality or Access (Sahni, Stein, Zemmel, & Cutler, 2023)*

Due to the numerous benefits of AI use in the healthcare sector, such as increased accessibility of healthcare services, efficient diagnostics in terms of cost and time, cost-effective treatments, and better preventive care services, countries continue to formulate strategies and rapidly invest in this field. As seen in the table below, 35 OECD countries have a strategy related to digital health, including artificial intelligence technology. These strategies contribute to the overall transformation of the healthcare system (OECD, 2023).

The 20 member countries of the European Union (EU) have published important policy proposals and initiatives in 2021 that will form the basis for the National Artificial Intelligence Strategy. Additionally, the European Union has proposed investing 7 billion Euros in artificial intelligence technology in the healthcare sector between 2021 and 2027.

Among the goals of the Chinese Government is to become the innovation center for Artificial Intelligence by 2030. The use of artificial intelligence technology in medical imaging is expected to grow by 40%, reaching $2.5 billion USD by 2024 (Innovation Centre Danimark, 2020).

In 2019, the market size for the use of artificial intelligence in healthcare services in South Korea was USD 44 million. The market size for using artificial intelligence in healthcare services is expected to reach USD 194 million by the end of this year. The primary area where artificial intelligence technology is used in the healthcare sector in South Korea is medical device software (Statistica, 2023).

In France, the Private Hospitals Association initiated a project in 2018 to promote the widespread use of artificial intelligence in healthcare. The project aims to establish ethical standards for the use of artificial intelligence in the sector, in addition to ensuring the compatibility of hospital algorithms and the appropriateness and security of data.

In India, AI spending increased by 108% in 2018, reaching $665 million USD. It is expected that these expenditures will reach $11.78 billion USD by the end of 2025. Additionally, expenditures on artificial intelligence technology in the healthcare sector are expected to contribute USD 1 trillion to the Indian economy by 2035 (PwC, 2023).

On a global scale, investments in healthcare technologies in 2021 in health technologies doubled compared to the previous year, exceeding USD 44 billion. Although there has been a decline in this rate in 2022 due to global economic and geopolitical challenges, it is still observed that investments continue to increase compared to the period before the Covid-19 pandemic.

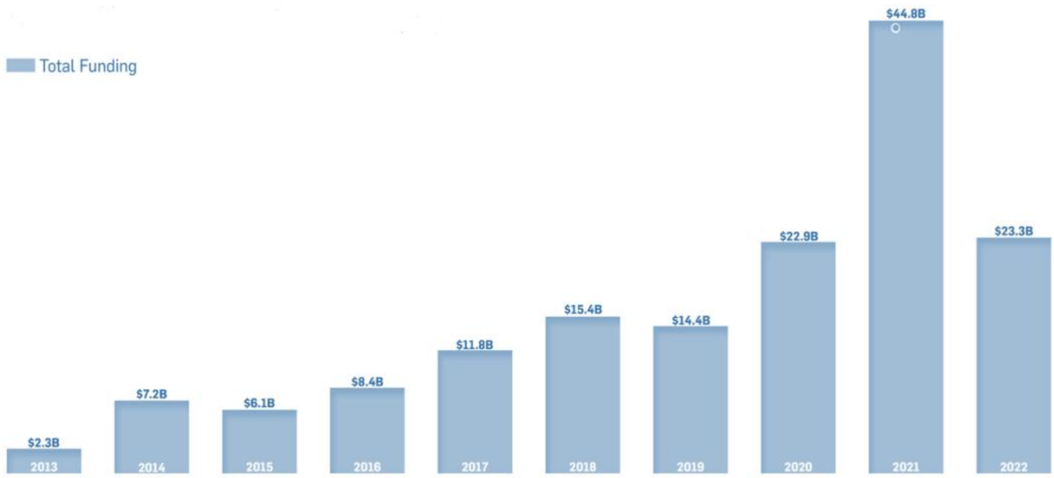

***Figure 28**:Investments in Healthcare Technologies*

The global artificial intelligence market in the healthcare sector amounted to 11 billion US dollars in 2021. It is estimated to be 15.1 billion US dollars in 2022 and is expected to exceed approximately 187.95 billion US dollars by 2030. The increase in investments made in this field by both the public and private sectors is expanding the artificial intelligence market in the healthcare sector (Statista, 2023).

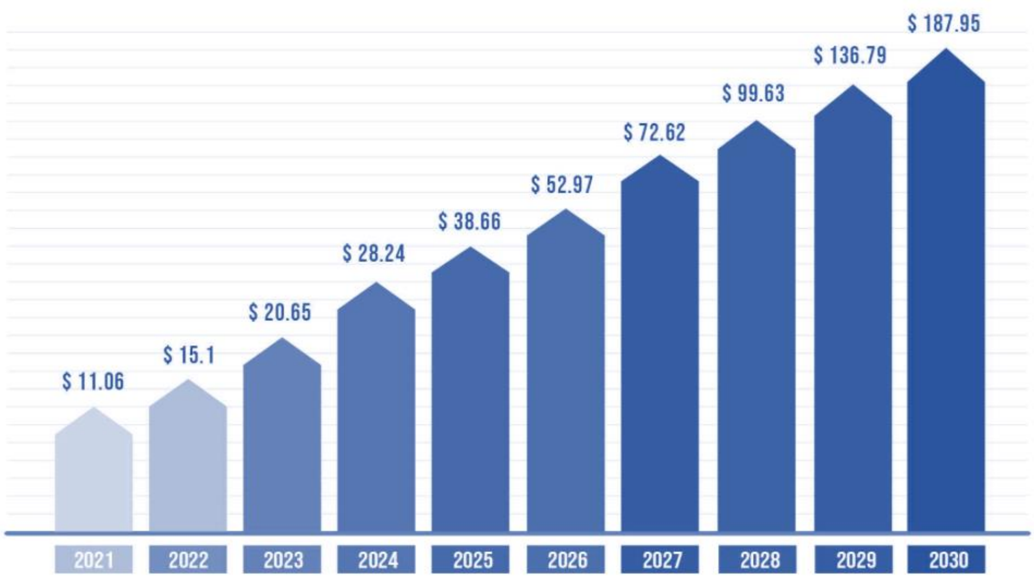

***Figure 29:**The Global Artificial Intelligence Investment in the Healthcare Sector (2021-2030)*

As can be seen, digitalization and artificial intelligence technology in healthcare significantly improve the quality and efficiency of healthcare services, ensuring effectiveness and reducing costs. Investments made by countries and the private sector for using this technology in healthcare are increasing yearly, and the market size is developing.

CONCLUSION

Health is crucial for both individuals and the general population, serving as a cornerstone for societies to live in prosperity and safety. From an economic perspective, health care services rank among the world's largest sectors, significantly impacting countries' economies in various ways, including well-being, sustainable development, and human capital. The health sector is undergoing rapid transformation and digitalization, driven increasingly by artificial intelligence (AI) technology.

However, contemporary healthcare systems face numerous challenges, including a growing population, the prevalence of non-communicable diseases, an aging population, an increase in the proportion of patients utilizing healthcare services, inadequate human resources, and cost pressures. The necessity of the digital transformation of the health sector to address these complex and escalating problems faced by the global health sector, a fundamental component of the world economy, is undeniable. New technologies are modernizing health services and automating the delivery of healthcare.

The use and effectiveness of artificial intelligence technology in the field of health are growing every day, contributing to efficiency and effectiveness in both clinical areas such as diagnosis, treatment, drug discovery, elderly care, and early intervention, as well as administrative areas like patient management and effective use of hospital capacity. It has been proven to restructure health service processes, reducing both managerial and clinical costs. In clinical processes, it accelerates diagnostic, diagnostic, and treatment processes, reduces human interaction, and improves service quality. This helps reduce costs for patients and governments, preventing resource wastage.

The World Health Organization predicts a global shortage of 18 million doctors, nurses, and other frontline health workers by 2030 (WHO; 2016-Global strategy on human resources for health: Workforce 2030). The use of artificial intelligence technology in the health sector automates labor and time-intensive tasks for healthcare personnel, allowing more efficient use of human capital. Artificial intelligence technology contributes to addressing the workforce shortage risk faced by the health sector by enabling savings in human resources.

Additionally, it does not seem feasible for artificial intelligence (AI) to completely replace health care workers, especially in the near future. This is because tasks performed by AI will always require doctor supervision. Over time, a division of tasks between AI and human clinicians could be established. Health care workers who refuse to collaborate with AI and fail to adapt to the digital transformation in the health sector may face the risk of losing their jobs over time. Contrary to expectations, the use of AI in the health sector is envisioned not to create unemployment but to create new job opportunities and save time for health care workers, thus offering a solution to the unemployment issue faced by the health sector.

The use of AI technology in health services is expected to contribute to improving public health and the development of countries. Healthy individuals enhance their knowledge and skills through education, thereby contributing to increased labor productivity, which positively impacts the growth and development levels of countries. In other words, a healthy society paves the way for the economic progress of nations and forms the foundation of development.

Despite the numerous economic benefits provided by AI, concerns about reliability, patient privacy, and ethical considerations persist. There are uncertainties regarding the allocation of responsibility in the event of potential issues. It is essential to address such security vulnerabilities and ethical concerns. Moreover, contrary to claims that the use of artificial intelligence in healthcare will reduce inequality, there are significant concerns that it may actually exacerbate disparities. Healthcare systems in developed countries may have more financial resources and infrastructure, enabling a more widespread adoption of artificial intelligence. This situation could lead to increased inequality in healthcare systems in less developed and developing countries. Access to the knowledge and skills required to develop, implement, and sustain artificial intelligence systems may also vary across different geographical regions and communities. Therefore, adopting equalityfocused policies and considering the needs of diverse communities are crucial to mitigate the potential of increasing inequalities in the use of artificial intelligence in the healthcare sector.

While there are many studies in the literature on the significant contributions of AI technology in the health sector, very few have conducted comprehensive economic assessments. Moreover, studies that have performed economic evaluations often exhibit methodological shortcomings.

This study focuses on the yet unexplored economic impacts of AI in the health sector, aiming to address the existing knowledge gap. The comprehensive research conducted unveils the potential economic contributions of AI in the health sector. The findings indicate that AI offers more economical solutions compared to traditional methods in health applications worldwide. The results demonstrate that AI enhances efficiency, reduces costs, and provides significant advantages, particularly in early diagnosis and treatment of diseases. Therefore, this study provides a crucial contribution that sheds light on future research on the economic effects of AI in the health sector.

The solution to global health problems lies in emerging technologies, primarily artificial intelligence. To overcome the increasingly complex challenges faced by the health sector daily, it is essential to adapt to technologies such as artificial intelligence. In this context, scientific studies examining the cost-effectiveness of AI are recommended to encourage its use in the future.

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APPENDIX 1. ETHICS COMMISSION FORM

	HACETTEPE ÜNİVERSİTESİ SOSYAL BİLİMLER ENSTİTÜSÜ	Doküman Kodu *Form No.*	FRM-YL-09
		Yayım Tarihi *Date of Pub.*	22.11.2023
	FRM-YL-09 **Yüksek Lisans Tezi Etik Kurul Muafiyeti Formu** *Ethics Board Form for Master's Thesis*	Revizyon No *Rev. No.*	02
		Revizyon Tarihi *Rev.Date*	25.01.2024

HACETTEPE ÜNİVERSİTESİ
SOSYAL BİLİMLER ENSTİTÜSÜ
İKTİSAT ANABİLİM DALI BAŞKANLIĞINA

Tarih: 31/01/2024

Tez Başlığı (Türkçe): SAĞLIKTA YAPAY ZEKANIN EKONOMİK ETKİLERİ

Yukarıda başlığı verilen tez çalışmam:

1. İnsan ve hayvan üzerinde deney niteliği taşımamaktadır.
2. Biyolojik materyal (kan, idrar vb. biyolojik sıvılar ve numuneler) kullanılmasını gerektirmemektedir.
3. Beden bütünlüğüne veya ruh sağlığına müdahale içermemektedir.
4. Anket, ölçek (test), mülakat, odak grup çalışması, gözlem, deney, görüşme gibi teknikler kullanılarak katılımcılardan veri toplanmasını gerektiren nitel ya da nicel yaklaşımlarla yürütülen araştırma niteliğinde değildir.
5. Diğer kişi ve kurumlardan temin edilen veri kullanımını (kitap, belge vs.) gerektirmektedir. Ancak bu kullanım, diğer kişi ve kurumların izin verdiği ölçüde Kişisel Bilgilerin Korunması Kanuna riayet edilerek gerçekleştirilecektir.

Hacettepe Üniversitesi Etik Kurullarının Yönergelerini inceledim ve bunlara göre çalışmamın yürütülebilmesi için herhangi bir Etik Kuruldan izin alınmasına gerek olmadığını; aksi durumda doğabilecek her türlü hukuki sorumluluğu kabul ettiğimi ve yukarıda vermiş olduğum bilgilerin doğru olduğunu beyan ederim.

Gereğini saygılarımla arz ederim.

Gökçe Nur DURAN

Öğrenci Bilgileri		
	Ad-Soyad	Gökçe Nur DURAN
	Öğrenci No	N20130190
	Enstitü Anabilim Dalı	İktisat
	Programı	İktisat Yüksek Lisans

DANIŞMAN ONAYI

UYGUNDUR.

Prof. Dr. Zafer ÇALIŞKAN

* Tez **Almanca** veya **Fransızca** yazılıyor ise bu kısımda tez başlığı **Tez Yazım Dilinde** yazılmalıdır.

	HACETTEPE ÜNİVERSİTESİ **SOSYAL BİLİMLER ENSTİTÜSÜ**	Doküman Kodu *Form No.*	FRM-YL-09
		Yayım Tarihi *Date of Pub.*	22.11.2023
	FRM-YL-09 **Yüksek Lisans Tezi Etik Kurul Muafiyeti Formu** *Ethics Board Form for Master's Thesis*	Revizyon No *Rev. No.*	02
		Revizyon Tarihi *Rev. Date*	25.01.2024

HACETTEPE UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
DEPARTMENT OF ECONOMICS

Date: 31/01/2024

ThesisTitle (In English): ECONOMIC IMPACT OF ARTIFICIAL INTELLIGENCE IN HEALTHCARE

My thesis work with the title given above:

1. Does not perform experimentation on people or animals.
2. Does not necessitate the use of biological material (blood, urine, biological fluids and samples, etc.).
3. Does not involve any interference of the body's integrity.
4. Is not a research conducted with qualitative or quantitative approaches that require data collection from the participants by using techniques such as survey, scale (test), interview, focus group work, observation, experiment, interview.
5. Requires the use of data (books, documents, etc.) obtained from other people and institutions. However, this use will be carried out in accordance with the Personal Information Protection Law to the extent permitted by other persons and institutions.

I hereby declare that I reviewed the Directives of Ethics Boards of Hacettepe University and in regard to these directives it is not necessary to obtain permission from any Ethics Board in order to carry out my thesis study; I accept all legal responsibilities that may arise in any infrigement of the directives and that the information I have given above is correct.

I respectfully submit this for approval.

Gökçe Nur DURAN

Student Information		
	Name-Surname	Gökçe Nur DURAN
	Student Number	N20130190
	Department	Economics
	Programme	Economics Master's

SUPERVISOR'S APPROVAL

APPROVED

Prof. Dr. Zafer ÇALIŞKAN

APPENDIX 2. ORIGINALITY REPORT

	HACETTEPE ÜNİVERSİTESİ SOSYAL BİLİMLER ENSTİTÜSÜ	Doküman Kodu *Form No.*	FRM-YL-15
		Yayım Tarihi *Date of Pub.*	04.12.2023
	FRM-YL-15 **Yüksek Lisans Tezi Orijinallik Raporu** *Master's Thesis Dissertation Originality Report*	Revizyon No *Rev. No.*	02
		Revizyon Tarihi *Rev.Date*	25.01.2024

HACETTEPE ÜNİVERSİTESİ
SOSYAL BİLİMLER ENSTİTÜSÜ
İKTİSAT ANABİLİM DALI BAŞKANLIĞINA

Tarih: 31/01/2024

Tez Başlığı: SAĞLIKTA YAPAY ZEKANIN EKONOMİK ETKİLERİ

Yukarıda başlığı verilen tezimin a) Kapak sayfası, b) Giriş, c) Ana bölümler ve d) Sonuç kısımlarından oluşan toplam 160 sayfalık kısmına ilişkin, 31/01/2024 tarihinde şahsım/tez danışmanım tarafından Turnitin adlı intihal tespit programından aşağıda işaretlenmiş filtrelemeler uygulanarak alınmış olan orijinallik raporuna göre, tezimin benzerlik oranı % 18'dir.

Uygulanan filtrelemeler*:

1. ☒ Kabul/Onay ve Bildirim sayfaları hariç
2. ☒ Kaynakça hariç
3. ☐ Alıntılar hariç
4. ☒ Alıntılar dâhil
5. ☒ 5 kelimeden daha az örtüşme içeren metin kısımları hariç

Hacettepe Üniversitesi Sosyal Bilimler Enstitüsü Tez Çalışması Orijinallik Raporu Alınması ve Kullanılması Uygulama Esasları'nı inceledim ve bu Uygulama Esasları'nda belirtilen azami benzerlik oranlarına göre tezimin herhangi bir intihal içermediğini; aksinin tespit edileceği muhtemel durumlarda doğabilecek her türlü hukuki sorumluluğu kabul ettiğimi ve yukarıda vermiş olduğum bilgilerin doğru olduğunu beyan ederim.

Gereğini saygılarımla arz ederim.

Gökçe Nur DURAN

Öğrenci Bilgileri		
	Ad-Soyad	Gökçe Nur DURAN
	Öğrenci No	N20130190
	Enstitü Anabilim Dalı	İktisat
	Programı	İktisat Yüksek Lisans

DANIŞMAN ONAYI

UYGUNDUR.

Prof. Dr. Zafer ÇALIŞKAN

* Tez **Almanca** veya **Fransızca** yazılıyor ise bu kısımda tez başlığı **Tez Yazım Dilinde** yazılmalıdır.
**Hacettepe Üniversitesi Sosyal Bilimler Enstitüsü Tez Çalışması Orjinallik Raporu Alınması ve Kullanılması Uygulama Esasları İkinci bölüm madde (4)/3'te de belirtildiği üzere: Kaynakça hariç, Alıntılar hariç/dahil, 5 kelimeden daha az örtüşme içeren metin kısımları hariç (Limit match size to 5 words) filtreleme yapılmalıdır.

	HACETTEPE ÜNİVERSİTESİ SOSYAL BİLİMLER ENSTİTÜSÜ	Doküman Kodu *Form No.*	FRM-YL-15
		Yayım Tarihi *Date of Pub.*	04.12.2023
	FRM-YL-15 **Yüksek Lisans Tezi Orijinallik Raporu** *Master's Thesis Dissertation Originality Report*	Revizyon No *Rev. No.*	02
		Revizyon Tarihi *Rev.Date*	25.01.2024

TO HACETTEPE UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
DEPARTMENT OF ECONOMICS

Date: 31/01/2024

Thesis Title (In English): ECONOMIC IMPACT OF ARTIFICIAL INTELLIGENCE IN HEALTHCARE

According to the originality report obtained by myself/my thesis advisor by using the Turnitin plagiarism detection software and by applying the filtering options checked below on 31/01/2024 for the total of 160 pages including the a) Title Page, b) Introduction, c) Main Chapters, and d) Conclusion sections of my thesis entitled above, the similarity index of my thesis is 18 %.

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I hereby declare that I have carefully read Hacettepe University Graduate School of Social Sciences Guidelines for Obtaining and Using Thesis Originality Reports that according to the maximum similarity index values specified in the Guidelines, my thesis does not include any form of plagiarism; that in any future detection of possible infringement of the regulations I accept all legal responsibility; and that all the information I have provided is correct to the best of my knowledge.

Kindly submitted for the necessary actions.

Gökçe Nur DURAN

Student Information		
	Name-Surname	Gökçe Nur DURAN
	Student Number	N20130190
	Department	Economics
	Programme	Economics Master's

SUPERVISOR'S APPROVAL

APPROVED.
Prof. Dr. Zafer ÇALIŞKAN

**As mentioned in the second part [article (4)/3]of the Thesis Dissertation Originality Report's Codes of Practice of Hacettepe University Graduate School of Social Sciences, filtering should be done as following: excluding refence, quotation excluded/included, Match size up to 5 words excluded.