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Derleme

Risk Analysis and Assessment of Artificial Intelligence Usage in Healthcare

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Abstract
This study aims to discuss key issues in the health sector in Turkey, focusing on a large-scale reform, evidence-based decision-making regarding innovative technologies and AI, stakeholder coordination, and monitoring of potential diseases and pandemics. The goal is to provide practical suggestions for AI usage in the health sector in Turkey. The researchers conducted literature reviews and searched for AI products/services online. AI offers innovative solutions across various sectors, including health. Advanced health technologies, such as gene-based, immune-based, and stem cell regeneration therapies and synthetic nano-biology, can lead to more predictive, preventive, corrective, personalized, and remotely collaborative health solution systems. The R&D process of health-related products and methods contains uncertainties, risks, and opportunities. Ethical concerns, social relations, and psychological and legal compliance levels are significant considerations for future AI applications. The importance of establishing long-term AI research and policies is emphasized while acknowledging the societal benefits provided by AI. The study suggests that Turkish authorities on integrating technological innovations into the health sector.

Keywords: Health MIS, Social good, Artificial intelligence, Industry 4.0, Society 5.0

Sağlık Hizmetlerinde Yapay Zeka Kullanımının Risk Analizi ve Değerlendirmesi

Özet

Bu çalışma, büyük ölçekli reform, yenilikçi teknolojiler ve yapay zeka (YZ) ile ilgili kanıta dayalı karar verme, yenilikçi teknolojiler ve (YZ) konusunda paydaş koordinasyonu ve potansiyel hastalıkların ve pandemilerin izlenmesine odaklanarak Türkiye'deki sağlık sektöründeki temel sorunları tartışmayı amaçlamaktadır. Amaç, Türkiye'de sağlık sektöründe YZ kullanımına yönelik uygulanabilir öneriler sunmaktır. Araştırmacılar literatür taramaları yaptılar ve çevrimiçi olarak YZ ürünlerini/hizmetlerini aradılar. YZ, sağlık da dahil olmak üzere çeşitli sektörlerde yenilikçi çözümler sunar. Gen bazlı, immün bazlı ve kök hücre rejenerasyon terapileri ve sentetik nano-biyoloji gibi ileri sağlık teknolojileri, daha öngörücü, önleyici, düzeltici, kişiselleştirilmiş ve katılımcı sağlık çözüm sistemlerine yol açabilir. Sağlıkla ilgili ürün ve yöntemlerin AR-GE süreci belirsizlikler, riskler ve fırsatlar içermektedir. Etik kaygılar, sosyal ilişkiler ve psikolojik ve yasal uyum seviyeleri, gelecekteki YZ uygulamaları için önemli hususlardır. YZ'nin sağladığı toplumsal faydaları kabul ederken, uzun vadeli YZ araştırmaları ve politikalarını oluşturmanın önemi vurgulanmaktadır. Çalışma, Türk yetkililerine sağlık sektörüne teknolojik yenilikleri entegre etme konusunda öneriler sunmaktadır.

Anahtar kelimeler: Sağlık YBS, Sosyal iyilik, Yapay zeka, Endüstri 4.0, Toplum 5.0

1. INTRODUCTION

Artificial intelligence (AI), the internet of things, virtual and augmented reality, digitization, biosensors, telemedicine, big data analytics, additive manufacturing, industry 4.0, robotics, metaverse, and smartphone applications have transformed many sectors. It has started to be used in corporate environments as well. As Health Management Information Systems (H-MIS) have evolved rapidly via sophisticated algorithms and auto-control capabilities, AI is now beginning to

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be recognized as part of the truth and reality, with incredible advancements in healthcare for financial control, trending, forecasting, disease diagnosis, analysis of diseases, and records management (Rajasekera, 2020). The gradual decrease in birth rates and the increasing life expectancy cause an increase in the elderly population in society (Kurtkapan, 2019). By 2050, one-fifth of the global population is projected to be over 60, and two-thirds of babies born today will live to 100 (WEF, 2019). The change in population structure, environmental changes, globalization of the world, and new diseases lead to a transformation in health and patient care (Kiper, 2013). This makes it necessary to identify elderly patients, treat them, and ensure they live healthier and longer lives without dependence. Currently, most causes of death are due to non-communicable diseases such as cancer, diabetes, respiratory and cardiovascular diseases. It is estimated that a total of US$ 30 trillion will be spent on diagnosing and treating these diseases over the next two decades (WHO, 2016). It is predicted that a growing and aging population, the ever-increasing burden of chronic diseases that represent 75% of health expenditures today, and the increasing cost of health services will cause a loss of approximately 47 trillion USD in the world's gross domestic product by 2030 (WEF, 2019). These situations necessitate AI-based solutions with traditional approaches that can work beyond human capabilities. However, AI is also disruptive with its innovations in the social sector (Rajasekera, 2020).

While the demand for health services is increasing, the rapidly increasing health costs negatively affect public resources. On the other hand, governments are under pressure to improve quality and facilitate access to care. In all regions except North America, average spending is expected to grow at a rapid pace annually in Africa (7.4%) and Asia (7.1%) (EIU, 2019). AI algorithms can diagnose by quickly reviewing millions of image scans for cancer symptoms, compensating for the lack of radiologists to handle the diagnostic burden, and megaprojects are heavily invested in similar applications.

Health is one of the essential areas subject to the Sustainable Development Goals and can affect all sectors. International organizations such as the World Health Organization (WHO) show where needs will lead worldwide and where the ecosystem should invest. The third element of the United Nations (UN) Sustainable Development Goals aims for all individuals to live a sustainable healthy life and defines targets. These targets include:

- Developing the ability of countries to manage the crisis in health-related crises,
- Reducing the death rate of mothers, newborn babies, and children under five years old and
- Supporting R&D in the fight against epidemics, communicable and non-communicable diseases.

AI for disease diagnosis, treatment recommendation, healthcare management, and other related applications can significantly contribute to Turkey's pursuit of Sustainable Development Goals and the objectives set by the World Health Organization. These goals are also addressed in the Eleventh Development Plan of Türkiye, which outlines specific targets and indicators to be monitored in the health sector. Moreover, the 2023 Industry and Technology Strategy of Turkey aims to foster the development of globally competitive products, technologies, and services that can reduce import dependency and boost exports. To achieve this, the strategy emphasizes the promotion of predictive, preventive, personalized, and optimized smart life systems, as well as advancements in healthcare systems for improved well-being.

In light of these objectives, it is anticipated that research and development, as well as innovation initiatives in information and clinical technologies, will pave the way for novel solutions in the healthcare industry. By harnessing the power of AI, Turkey can enhance disease diagnosis accuracy, provide tailored treatment recommendations, streamline healthcare management processes, and facilitate the creation of sustainable and efficient health systems. This aligns with the country's broader aspirations for economic growth and technological advancement in the healthcare sector.

1.1. Research problem statement

The health sector in Turkey faces the challenge of an increasing elderly population, rising health costs, and a growing burden of non-communicable diseases. To address these challenges, there is a need for innovative solutions that can work beyond human capabilities, and artificial intelligence (AI) has the potential to offer predictive, preventive, corrective, personalized, and remotely collaborative health solution systems. However, the development and implementation of AI-based solutions require large-scale reform, evidence-based decision-making, coordination of stakeholders, and monitoring of potential risks and uncertainties.

1.2. Research assumptions

1. The use of AI in the health sector can provide innovative solutions that can work beyond human capabilities and offer predictive, preventive, corrective, personalized, and remotely collaborative health treatment systems.
2. The development and implementation of AI-based solutions require large-scale reform, evidence-based decision-making, coordination of stakeholders, a certain level of awareness of risks and benefits, a high level of skilled users, and monitoring of potential risks and uncertainties.
3. The societal benefits of AI in the health sector cannot be ignored, but there are significant concerns over the ethical understandings of future AI applications, the requirements of afterlife beliefs and expectations, the environment of peace, social relations, and psychological and legal compliance levels.

1.3. Hypothesis

AI in the health sector can significantly improve health outcomes and reduce health costs in Turkey, provided that there is large-scale reform, evidence-based decision-making, coordination of stakeholders, and monitoring of potential risks and uncertainties. However, the ethical concerns and potential negative impacts of AI applications need to be carefully considered and addressed to ensure that the benefits of AI in the health sector are realized without compromising social well-being, environmental sustainability, religious requirements and ethical principles.

2. THE LITERATURE

Studies in Google Scholar reveal the increasing interest of scientists in smart life issues, especially in the last five years. Because all ideas about smart living and social well-being have a complexity beyond what can be inferred from datasets, much of what we want to influence is not directly measurable or controllable. For this reason, the United Nations General Assembly has issued a resolution dated 21.12.2020 and numbered 75/131 (https://undocs.org/pdf?symbol=en/A/RES/75/131).

It is important to acknowledge that when regulating AI-related applications, it is crucial to consider not only the tangible aspects and the transient nature of our earthly existence but also the post-mortem expectations held by individuals of various beliefs. It should be noted that existing regulations and public circulars often fail to emphasize the essential preparations for the afterlife, which is an inevitable reality for every person. This failure undermines the significance of material possessions and how they can be attained in a harmonious manner. Instead, these measures tend to focus primarily on temporary solutions pertaining to our finite lifespan. In this context, recognizing that the aging of the population will continue to affect all aspects of society, including the demand for goods and services such as labor and financial markets, health, housing, education, long-term care, social protection, transport, information, and communication, and improving intergenerational ties.

It is also evident that there is a great interest and concern towards smart living tools, techniques, risks and benefits, the literature on the areas, as is seen in Figure 1 below, has shown a dramatic increase in the number of publications.

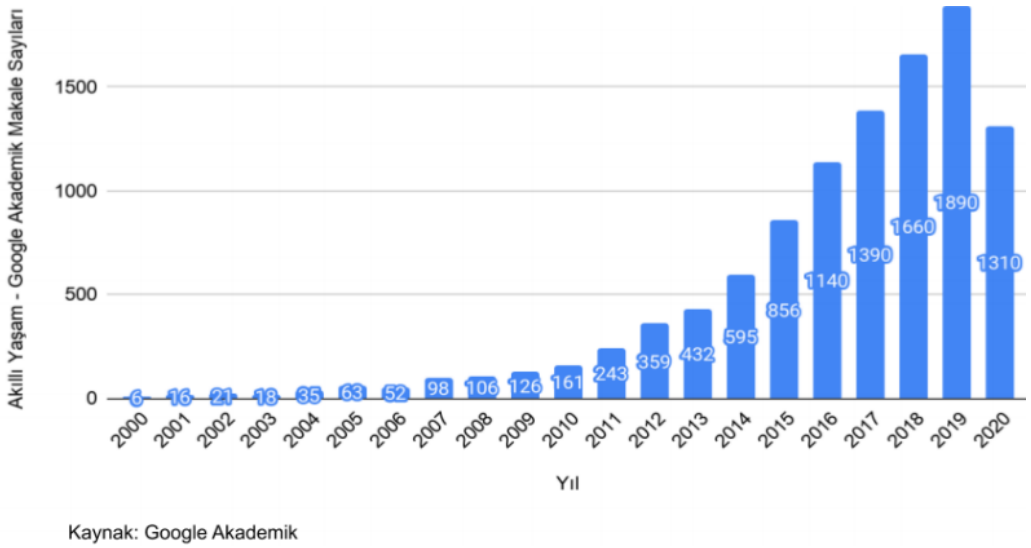

Figure 1. Number of articles available in the google scholar academic database in the field of smart living

1. The United Nations has declared 2021-2030 the Decade of Healthy Aging.
2. Welcomes the Decade of Healthy Aging proposal, which provides a program of work with voluntary policy options and strategies for use.
3. Encourage Member States and other stakeholders to act and strengthen these measures.
4. Recognize that older people's enjoyment of all human rights challenges in different fields and these challenges require in-depth analysis and action.
5. The Interagency Aging Group using existing coordination mechanisms.
6. Governments and other relevant stakeholders, including international and regional organizations, civil society, the private sector, academia, and the media, are invited to actively support the implementation of the United Nations Decade of Healthy Aging (2021-2030), including through voluntary contributions.

It has become a severe problem for countries and institutions as traditional structures for the elderly, the disadvantaged, and those with health problems have become inefficient and excessively costly. The above-referenced calls of bodies such as the United Nations are often not answered. For this reason, it has become a necessity to benefit from AI applications within the scope of Society 5.0, in which the strategy, policy, objectives, investments, processes, and activities must be structured and aligned correctly and proactively.

In addition to addressing broader issues and concepts in AI research for public welfare, it is crucial to recognize the distinct aspects involved. Firstly, the primary focus lies on promoting well-being and its direct impact on people's lives. The second significant challenge entails comprehending, diagnosing, and framing problems in consideration of the social dynamics within the population. The third challenge involves individuals not evenly distributing their life resources, thereby jeopardizing their prospects for continued existence and happiness, which may affect their spiritual well-being after death and extend to their loved ones and relatives. Within the context of these challenges, numerous fundamental and applied research problems await resolution. Some of these include:

1. Developing predictive simulations or models that offer decision-making information and can be adapted in a "closed-loop" manner as additional data becomes available over time.

2. Designing implementation strategies for life resources that take into account the soul, emotions, thoughts, and desires of individuals, ensuring the continuity and happiness of both their worldly existence and their relationships with loved ones.
3. Creating advanced models for decision-making and planning that incorporate resource limitations, social dynamics, and utility models involving multiple actors.
4. Establishing machine learning and data analytics models that are resilient against systematic bias, missing data, and data heterogeneity.
5. Developing cost-effective, reliable, and scalable data collection or measurement models.
6. Designing causal reasoning and explanation methods.

It is important to emphasize that these fundamental AI problems must be combined with broader computer science innovations (Probst et al., 2014). Digital transformation and AI can form the basis of new healthcare models as a driving force in the use of cheaper, more sensitive, and fewer treatments with predictive, preventive, personalized, optimized medicine solutions, and real-time monitoring of healthcare, taking into account the eternal expectations of human beings and spiritual food. The coordination of the ecosystem, which focuses solely on material measures and consists of stakeholders in different structures such as research and development, higher education, entrepreneurship, health service delivery, health financing, the pharmaceutical and medical device industry, and intelligent information technology products, is of critical importance (WEF, 2019). It is essential for ecosystems to consider not only the materialistic aspects and the transient nature of our earthly existence but also the post-mortem expectations held by various belief systems. Merely focusing on projections and interventions until death, which claim the lives of approximately 160 thousand individuals daily and strip them of their all material possessions, would ultimately lack meaning in the grand scheme of things.

3. RISK ASSESSMENT AND EVALUATION

Super AI, or Artificial Intelligence, has gained significant attention in recent years in various fields, including healthcare. The integration of AI in the healthcare system can help in better decision-making, improved diagnosis and treatment outcomes, and reduced costs. However, the integration of super AI in healthcare comes with risks and concerns that need to be identified and addressed. In this essay, we will provide a detailed risk assessment and risk evaluation of the usage of super AI applications in hospitals, medical, and healthcare systems.

3.1. Safety Risk

The integration of AI in healthcare may pose a safety risk to patients if the AI system malfunctions or fails to provide accurate information. There have been instances where AI algorithms have made incorrect diagnoses, leading to adverse patient outcomes. The use of AI in healthcare must undergo rigorous testing and validation before implementation to ensure its safety and effectiveness (Topol, 2019).

3.2. Security Risk

The integration of AI in healthcare can also pose a security risk to patient data. AI systems require large amounts of patient data to learn and improve their algorithms, which makes them vulnerable to data breaches and cyber-attacks. There have been instances where healthcare organizations have been targeted by cybercriminals, leading to the theft of patient data (He et al., 2019). The implementation of AI in healthcare must include robust cybersecurity measures to ensure patient data is protected.

3.3. Ethical Risk

The integration of AI in healthcare raises ethical concerns, particularly in the area of patient privacy and informed consent. AI algorithms may use patient data to learn and improve their algorithms, which raises concerns about how patient data is collected and used. Additionally, AI systems may be biased, leading to unequal treatment of patients based on factors such as race or gender (Price et al., 2019). The implementation of AI in healthcare must address these ethical concerns to ensure that patients' rights are protected.

3.4. Liability Risk

The integration of AI in healthcare may pose liability risks to healthcare providers if the AI system malfunctions or fails to provide accurate information, leading to adverse patient outcomes. Additionally, healthcare providers may face liability if they rely solely on AI algorithms for diagnosis and treatment decisions without considering other factors, such as patient history or clinical expertise (Forcier et al., 2020). Healthcare providers must ensure that they maintain their clinical expertise and use AI algorithms as an aid in decision-making. The risks associated with the integration of super AI in healthcare must be evaluated against the benefits. The use of AI in healthcare can improve patient outcomes, reduce costs, and increase efficiency. However, the risks associated with the use of AI in healthcare, such as safety, security, ethical, and liability risks, must be addressed to ensure patient safety and privacy. Therefore, the integration of super AI in healthcare has the potential to transform the healthcare system. However, it also comes with risks and concerns that need to be identified and addressed. The risks associated with the use of super AI in healthcare include safety, security, ethical, and liability risks, which must be evaluated against the benefits to ensure patient safety and privacy. The implementation of AI in healthcare must include rigorous testing and validation, robust cybersecurity measures, and addressing ethical concerns to ensure patients' rights are protected.

4. GLOBAL ACTORS AND MARKET PREDICTIONS

According to a report by MarketsandMarkets, the global artificial intelligence in the healthcare market is expected to grow from $2.1 billion in 2018 to $36.1 billion by 2025, at a CAGR of 50.2% (Markets and Markets, 2019). This significant growth is attributed to the increasing need for improved healthcare services, the rising adoption of electronic health records, and the growing availability of big data in healthcare.

Market actors such as IBM, Google, and Microsoft are heavily investing in AI healthcare technologies. For instance, IBM Watson Health is collaborating with healthcare providers and research institutions to develop AI-powered tools for diagnosis, treatment, and drug discovery. Google has also established partnerships with healthcare providers to develop predictive algorithms that can help prevent medical errors and improve patient outcomes.

Other companies that are leveraging AI in healthcare include Qualcomm Life, Philips Healthcare, and Medtronic. These companies are developing AI-powered devices, wearables, and software applications that can help healthcare providers in decision-making, diagnosis, and treatment.

The use of AI in healthcare has numerous benefits, including faster diagnosis, improved treatment outcomes, and reduced costs. For instance, AI-powered tools can analyze large amounts of medical data and identify patterns that can help clinicians make more accurate diagnoses. AI-powered devices can also monitor patient vitals in real-time and alert healthcare providers of any changes in the patient's condition.

However, there are also challenges associated with the use of AI in healthcare, such as data privacy concerns and the potential for bias in algorithms. It is important for companies and

healthcare providers to ensure that AI-powered technologies are developed and deployed in an ethical and responsible manner.

Futurist projections suggest that the use of AI in healthcare will continue to grow in the coming years. According to a report by Grand View Research (GVR), the global healthcare AI market is expected to reach $31.3 billion by 2025 at a CAGR of 41.5% (GVR, 2019). This growth is attributed to the increasing demand for personalized medicine, the growing use of electronic health records, and the need for improved patient outcomes.

In conclusion, the use of AI in healthcare is rapidly growing, with market actors such as IBM, Google, and Microsoft heavily investing in AI healthcare technologies. The future projections suggest that the growth of AI in healthcare will continue, with numerous benefits and challenges associated with its use. Companies and healthcare providers need to ensure that AI-powered technologies are developed and deployed ethically and responsibly.

4. USING NEURAL NETWORKS ARTIFICIAL INTELLIGENCE FOR SOCIAL GOOD AND SEARCHING FOR INTELLIGENT LIFE IN THE UNIVERSE

There is a faster search for life opportunities in areas outside the Earth with artificial intelligence models (Chou, 2018). It is advancing the work of the Kepler spacecraft, which the space agency uses to search for other suitable planets (Chodosh, 2017; Chen, 2017; Johnson, 2018). While machine learning has previously been used to analyze Kepler's data, a deep learning neural network approach has been introduced to the problem. (Shallue & Vanderburg, 2011). AI4SG has received much attention from the research community over the last decade with several successful applications (Ryan et al., 2020). For an AI system to be effective, it must have developed sensitivity to the specific contexts it is in and their social and ethical limits and approximate its people's emotional and cognitive states (Berbereich et al., 2020).

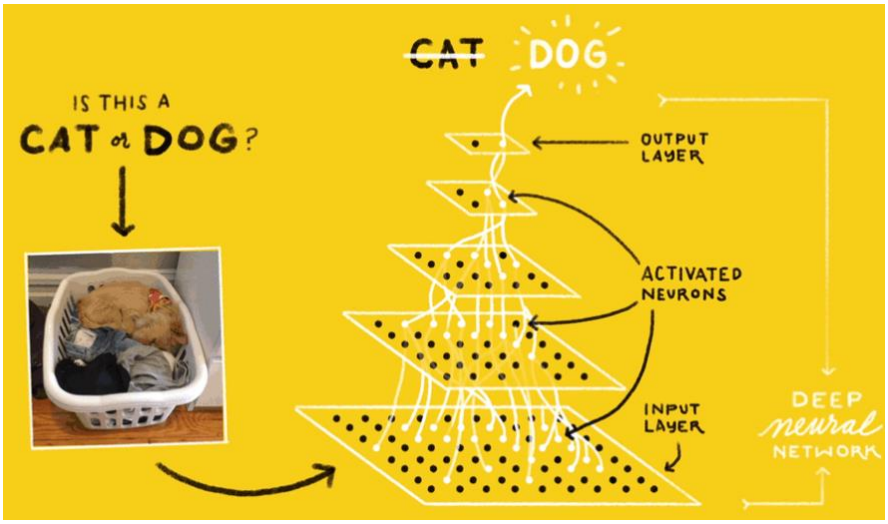

Figure 2. A demonstration of AI fuzzy logic structure Source (Chen, 2017).

As is demonstrated in Figure 2 in an example differentiation fuzzy logic structure, an application of fuzzy logic in smart living is in the field of ambient intelligence, which focuses on creating environments that are responsive, personalized, and adaptable to individuals' needs. Fuzzy logic algorithms are used to model human preferences and interpret sensor data to create intelligent systems that can automatically adjust the environment's parameters, such as lighting, temperature, and audio levels, based on individual preferences. For example, a smart home system can use fuzzy logic to interpret user preferences for comfort and energy efficiency and dynamically adjust heating and cooling settings accordingly (Zadeh, 2008).

Moreover, fuzzy logic is also employed in decision-making systems that involve multiple criteria and subjective assessments. In smart living applications, fuzzy logic can be used to assess and prioritize user preferences and make decisions accordingly. For instance, in a smart city context, fuzzy logic algorithms can analyze various factors such as traffic congestion, air quality, and energy consumption to optimize the routing of public transportation systems, improving efficiency and reducing environmental impact (Mamdani & Assilian, 1975).

Real-life AI examples are implemented in about a third of these cases, albeit in relatively minor tests. These range from helping blind people navigate their environment to diagnosing cancer, identifying online sexual exploitation, and helping disaster relief efforts (like the flooding that followed Hurricane Harvey in 2017). However, AI is only one part of a much broader precautionary toolkit that can be used to tackle societal problems. For now, issues such as data accessibility and lack of AI capability limit its application for social good (Chui et al., 2018). This work is divided into four parts:

1. Overcoming bottlenecks, particularly concerning data and talent
2. AI that can be used for social good
3. Risks to be managed
4. Mapping AI use cases to social benefit domains

5. MAPPING AI USE CASES TO SOCIAL BENEFIT DOMAINS

A study conducted by Arnfeld (2021) examined people's perceptions of the risks and benefits associated with AI use cases in different domains and investigated potential differences between these domains. The findings revealed variations in the perceived risks and benefits between the healthcare domain and the e-commerce/marketing domain. Notably, the healthcare domain received higher ratings for both perceived risks and benefits.

5.1. Economic empowerment

AI has the potential to play a crucial role in crisis response by detecting, understanding, and predicting the spread of diseases, providing early warning signs, and informing effective measures (van der Schaar, 2020). In the context of the pandemic, AI can enhance medical response in various ways. Firstly, it can automate diagnostics, enabling faster and more accurate identification of diseases (Wang, 2020). Secondly, AI can aid in prioritizing health resources, ensuring efficient allocation based on demand and severity of cases (Butt et al., 2020). Thirdly, AI can support doctors by facilitating the development of vaccines and drugs through improved research and analysis (Zhang et al., 2020a). Furthermore, AI can contribute to combating online misinformation related to COVID-19, helping to ensure accurate information reaches the public (Tzachor et al., 2020). Additionally, AI has applications in addressing crisis-related challenges, such as search and rescue missions during natural and artificial disasters and disease outbreaks.

The utilization of big data-based models can be valuable for psychometric assessments, particularly in predicting loan repayment behavior by analyzing applicant responses, beliefs, performance, attitudes, and integrity (Kandpal & Khalaf, 2020).

5.2. Education challenges

With the advancement of AI technology, patient-oriented applications have emerged in the healthcare sector, emphasizing the importance of incorporating artificial intelligence-related content into educational curricula to prepare future healthcare professionals (Yilmaz et al., 2021). However, there is limited knowledge regarding the perceptions and acceptance of AI-driven, patient-centered healthcare systems among the general public (Zhang et al., 2020b). In the era of personalized medicine, where healthcare focuses on individuals rather than populations, AI has

demonstrated its ability to learn and has found applications in various medical fields, including radiology (Tran et al., 2019).

5.3. Environmental challenges

Artificial intelligence knowledge-based techniques have been integrated into various aspects of environmental protection, such as monitoring, data analysis, communication, and information storage and retrieval, aiming to enhance efficiency and effectiveness in these tasks (Zhang et al., 2020a).

5.4. Equality and Inclusion

An example of an AI use case in the context of equality and inclusion involves the automation of emotion recognition and provision of social cues to assist individuals on the autism spectrum, as demonstrated by the work of Affectiva and Autism Glass, a Stanford research project from the MIT Media Lab (Porayska-Pomsta & Rajendran, 2019). However, it is important to note that AI decision-making lacks certain aspects found in human decision-making, such as individual flexibility, context-related judgments, empathy, and complex moral judgments (Porayska-Pomsta & Rajendran, 2019).

5.5. Health

According to Pham et al. (2021), incorporating ethno-racial education data into predictive models can enhance their accuracy due to the observed ethnic and racial variations in diabetes biomarkers, prevalence, and outcomes. This inclusion of diverse ethnic and racial information can lead to more targeted and effective healthcare interventions.

As AI-enabled telehealth becomes increasingly prevalent, it is crucial to consider important social and ethical factors within the healthcare system, as highlighted by Kuziemsky et al. (2019). These considerations should address the potential impact of AI on patient privacy, data security, equity in access to healthcare services, and the preservation of the doctor-patient relationship.

A groundbreaking disease detection AI system developed by researchers from Heidelberg University and Stanford University has demonstrated superior performance compared to professional dermatologists. This system employs visual diagnosis of natural images, such as skin lesions, to accurately determine if they are cancerous (AFP, 2018). The advancement of such AI technology has significant implications for improving early diagnosis and treatment outcomes in dermatology.

Brando et al. (2018) found that AI-powered wearables analyzing heart rate sensor data can achieve an 85 percent accuracy in identifying individuals with potential early signs of diabetes. These wearable devices, if made affordable and accessible, have the potential to benefit over 400 million people worldwide who are affected by diabetes by enabling early detection and intervention.

Yılmaz and Ölçer (2021) highlight the integration of artificial intelligence and robotics in the field of surgery, leading to the development of specialized robotic systems for different surgical disciplines. These advancements have the potential to enhance surgical precision, improve patient outcomes, and revolutionize various surgical procedures.

In the healthcare domain, artificial intelligence finds applications in several areas, such as medical imaging, medical records management, the pharmaceutical industry, robotics, big data analysis, early diagnosis, treatment planning, error reduction, and avoidance of unnecessary treatments. This comprehensive utilization of AI aims to improve healthcare delivery and patient outcomes while ensuring efficiency and personalization. However, it is essential to strike a balance between technology integration and the preservation of human emotions and the role of healthcare professionals (Can et al., 2021).

Didi Chuxing (DiDi), a mobile transportation platform provider, has embarked on the AI for Social Good project, which is considered the first AI project for social good. With over 10 co-founders and initiated by Union University's College of Special Education, DiDi aims to develop robust AI capabilities that will significantly contribute to social welfare. This project serves as an exemplary model for similar initiatives worldwide, aiming to leverage AI technology for the betterment of society.

6. ARTIFICIAL INTELLIGENCE CAPABILITIES THAT CAN BE USED FOR SOCIAL GOOD

Artificial intelligence (AI) capabilities have shown significant potential for social good. AI models have proven to outperform humans, particularly in scenarios that involve rapid processing and analysis of vast amounts of data (Chui et al., 2018). For instance, AI can be utilized to track disease outbreaks by analyzing tweets written in multiple languages, providing valuable insights for public health surveillance (CBC, 2016). Moreover, AI tools employing emotion recognition and face detection techniques can enhance educational opportunities by assisting children in identifying and learning the facial expressions of family members and friends (CBC, 2016).

Several case studies in the health sector demonstrate the transformative impact of AI:

Case Study 1: Deep Learning for Diabetic Retinopathy Detection Gulshan et al. (2016) conducted a study where they developed a deep learning algorithm to detect diabetic retinopathy, a complication of diabetes that leads to retinal blood vessel damage and potential vision loss. The researchers trained their algorithm using a dataset of 128,175 retinal images, which were expert-labeled for the presence of diabetic retinopathy. The deep learning model achieved an impressive area under the receiver operating characteristic curve (AUC-ROC) of 0.99, showcasing its high accuracy in identifying the disease (Gulshan et al., 2016).

Case Study 2: AI-Powered Chatbot for Mental Health Support Fitzpatrick et al. (2017) conducted a randomized controlled trial to evaluate the effectiveness of Woebot, an AI-powered chatbot that provides cognitive-behavioral therapy (CBT) to young adults experiencing symptoms of depression and anxiety. The study revealed that participants who engaged with Woebot for two weeks reported significant reductions in depressive symptoms compared to the control group, highlighting the potential of AI-powered chatbots in delivering mental health support (Fitzpatrick et al., 2017).

Case Study 3: Predicting Patient Deterioration Using Machine Learning Henry et al. (2015) aimed to enhance patient outcomes by developing a machine learning model called TREWScore to predict the onset of septic shock, a life-threatening condition associated with infections. The study utilized electronic health record (EHR) data from a cohort of over 16,000 patients and compared the performance of the TREWScore with existing early warning scores. The results demonstrated that the TREWScore achieved higher accuracy and provided an earlier indication of septic shock, enabling timely intervention and potentially saving lives (Henry et al., 2015).

These case studies exemplify the immense potential of AI in benefiting society, particularly in healthcare. By leveraging AI capabilities, such as deep learning algorithms, AI-powered chatbots, and machine learning models, we can enhance disease detection, mental health support, and patient care, ultimately contributing to improved outcomes and well-being for individuals and communities.

7. TECHNIQUES AND COMPANIES THAT CAN BE USED FOR SMART LIVING

We have conducted a search for AI tools and techniques available online on the internet. Table 1 contains all tools that we have found through internet searches.

Table 1. Results of internet search for AI tools that are available online

Name	Definition	Address
Abrasion	It helps manage persons inside a searchable database	www.etch.ai
Find	Intelligent call assistant thoughtful emails, Folders, and personal cloudy	www.findo.com
Splash	Recommends organizations for reference based on Skills	www.splash.ai
Mosaic	Helps joyful with writing better CVs	www.mosaic.ai
Newton	Helps find the type of job	www.newton.ai
woo	Helps make smart career decisions anonymously	www.woo.io
brightcrowd	Helps find important professional connections	www.brightcrowd.com
eezy	helps plan the evening by letting enjoy it according to current mood, resources, or preferences.	www.eezy.ai
thirdleap	Helps kids learn math	www.thirdleap.ai
woogie	A robot that makes learning and exploring fun for kids	www.woogie.ai
Brother	Virtual health assistant	www.abi.ai
Island	Can help if sick	www.ada.com
air	Personal health coach	www.airi.ai
amelie	A chatbot for mental health	www.amelie.ai
sleep	Diagnoses causes of snoring and bruxism (teeth grinding)	www.sleep.ai
Amazon Echo / Alexa	Amazon's personal assistant	www.amazon.com/Amazon-Echo-Bluetooth-Speaker-with-WiFi-Alexa/dp/B00X4WHP5E
apple Siri	iPhone and Match PA	www.apple.com/ios/siri/ _
Cortana	PA on Windows-based PC systems	www.microsoft.com/en-us/ www.mobile/experiences/cortana/
Google assistant	Google PA	www.assistant.google.com
Facebook M	Siri, now and Cortana rival	
Mycroft	The first open-source PA in the world	www.mycroft.ai
Spoken	Virtual assistant with an interface	www.spoken.ai
Viv	Siri rival	www.viv.ai
Evie	Meeting planning assistant	www.evie.ai
Zoom	Here is the personal assistant to help	www.zoom.ai
Chatfuel	Create a Facebook chatbot every 7 minutes	www.chatfuel.com
Luke	A chatbot Messenger for humans and other chatbots	www.luka.ai
MyWave	A chatbot that helps in daily life	www.mywave.me
News 360	Learn whatever want and find exciting stories	www.news360.com
Mara	An app that works smart	www.mara.ai
Pandora	Find music might like	www.pandora.com
Docubot	Can advise on legal questions	www.aux.ai
Firedrop	Automatically designed websites added and published content	www.firedrop.ai
Hashley	Hashtag generator and ironic comments for photos	www.hash.ai
Microsoft Translator	Powered by neural networks	www.translator.microsoft.com/neural

8. ASSESSMENT OF NATIONAL STRATEGY AND GOALS

Within the scope of the Smart Life and Health Products and Technologies Roadmap, sectoral, technological, and health transformation trends were evaluated in the 2023 Strategy Document of the Ministry of Industry and Technology. The needs have been revealed by analyzing Turkey's situation and the world. Studies were carried out by meeting with the Ministry of Health, the Investment Office of the Presidency, the relevant Ministries and other key stakeholders. As a result, 12 strategic objectives, 5 sub-targets, 34 actions, and 5 critical project proposals that emerged during the short, medium, and long-term strategic goals have been determined.

The global healthcare industry is witnessing a profound and exciting transformation. Along with the increase and aging of the global population, chronic diseases are spreading and increasing, and resources are becoming less and less limited. However, many studies have shown that social factors such as diet, exercise, work and living conditions are more important than health care, especially when it comes to healthy aging and the prevention of chronic diseases.

Smart Living and Health focuses on preventing disease by enabling people to become more active in managing their health and well-being and being more connected to their communities. Advanced clinical technologies (i.e., genomics, immuno and regenerative therapies, synthetic biology) and information technologies (i.e., artificial intelligence, internet of things, virtual and augmented reality, digitization, biosensors, telemedicine, big data and analytics, additive manufacturing, robotics and smartphone applications) showed rapid development and expansion to enable the transition towards a more predictive, preventive, personalized and remotely collaborative healthcare system. Large-scale reforms like this involve uncertainties and opportunities that will require stakeholder coordination, evidence-based decision-making, close monitoring of patients, and investment in research and development and initiatives.

The AI-based "Big Brain" Project (TCCB-DDO, 2020), initiated by the Presidency of the Republic of Turkey, represents a pioneering effort to utilize AI for health programs. Its primary objective is to enhance the effectiveness and efficiency of the diagnosis process, particularly for patients with brain tumors, by leveraging advanced deep-learning techniques to examine magnetic resonance (MR) images. The project has successfully integrated this study into a healthcare institution's system, providing invaluable support to radiologists. Rather than replacing doctors, the project aims to serve as a decision support system that facilitates their work. Notably, this project is the first of its kind in our country, showcasing its implementation and exemplifying its potential value in generating significant advancements through AI algorithms.

In its initial phase, the project involved training artificial intelligence algorithms using labeled brain MR images from 100 individuals, including 50 with high-grade glial tumors. A team of medical professionals, working in accordance with strict ethical guidelines and ensuring the confidentiality of personal data, applied 12 different labels to classify normal and abnormal structures in 8,000 sections of these images. This one-year intensive effort, carried out by a collaboration between academicians from Gazi University's Department of Neurosurgery and Engineering Faculty and six scholars from the Presidential Digital Transformation Office, has paved the way for a new era in our country's healthcare system. The impact of this national and globally recognized product is remarkable. It significantly reduces the workload of healthcare personnel and drastically shortens the time required for the result stage of MR examinations. Within a mere 5 to 10 seconds after a patient's MR scan is completed, the artificial intelligence algorithm ensures that the radiologist receives the ready-to-evaluate results. This swift turnaround time, coupled with a commitment to minimal errors, allows for prompt decision-making and immediate integration into the decision support system. Patients can benefit from the AI algorithm's output even before leaving the MR device, streamlining the overall diagnostic process. As the project progresses, the next phase involves expanding its installations to hospitals across the country. This initiative promises to revolutionize the healthcare sector by harnessing the power

of artificial intelligence in the realm of health, thanks to the dedication and expertise of the collaborating team of academics.

Within the scope of the Smart Life and Health Products and Technologies Roadmap, the targets set in the 2023 Strategy Document of the Ministry of Industry and Technology as is briefly demonstrated in Table 2, sectoral trends, technological trends, and health transformation trends were evaluated. As a result of the analysis, 12 strategic objectives, 5 strategic objectives, 34 policy/action plans and 5 critical project proposals have emerged. Strategic goals, objectives, and strategies are planned to be realized between 2020-2030.

Table 2. Strategy document of the ministry of industry and technology

No	Scope	Aim
SH1	Increasing the number of initiatives in the field of smart living and aging* ** nutrition, sleep, sports, exercise, home security, socialization, health literacy, stress management, sunbathing, healthy working, ergonomics, fight against addiction, water-air quality, time management*	Currently, there are approximately 50 initiatives in the specified areas. It is aimed that the number of enterprises will be 100 by 2025. (It can be followed on the start-up watch.)
SH2	Increasing the number of initiatives that develop the technologies foreseen for the prevention of chronic diseases* **diabetes, respiratory diseases, heart diseases, mental diseases, cancer*	Currently, there are approximately 25 initiatives in the specified areas. It is aimed that the number of enterprises will be 50 by 2025.
SH3	Increasing the number of initiatives that develop smart, new and domestic technologies for the diagnosis, treatment, control and management of chronic diseases* **diabetes, respiratory diseases, heart diseases, mental diseases, cancer*	Currently, there are approximately 25 initiatives in the specified areas. It is aimed that the number of enterprises will be 50 by 2025 and 120 by 2030.
SH4	Increasing the export-import coverage ratio in the pharmaceutical industry	It was calculated as 24% in 2019. By 2030, this rate is targeted to be 50%.
SH5	Increasing the rate of meeting the domestic market demand of local pharmaceutical manufacturers	Currently, the domestic pharmaceutical manufacturers' rate of meeting the demand in the domestic market is approximately 15%. By 2023, it is aimed that the domestic market coverage rate of local producers will be 30%.
SH6	Reducing imports on the basis of box and value in the pharmaceutical industry	It is known that 48% on a value basis and 88% on a box basis were manufactured in the Turkish prescription drug market in 2019. In 2030, it is aimed to manufacture prescription drugs at a rate of 60% on a value basis and 94% on a box basis.
SH7	Increasing the import coverage ratio of exports in the medical device sector	It is calculated as 29% in 2019. By 2030, this rate is targeted to be 52%.
SH8	Growth of domestic manufacturer share in the medical device market	The share of domestic manufacturers in the medical device market is targeted to grow by 10% annually until 2025.
SH9	Increasing the number of medical device patent applications	In 2018, 736 foreign and 510 local medical device patent applications were made. In 2023, the number of domestic medical device patent applications is targeted to be 1100.
SH10	Increasing the number of drug patent applications	In 2018, 2041 foreign and 355 local drug patent applications were filed. It is aimed that the number of domestic drug patent applications will be 500 in 2023.
SH11	Increasing the number of publications	In 2020, 40,338 publications on Smart Life and Health were realized in DergiPark Akademik. It is aimed to increase this rate by 40% annually until 2030.

SH12	Increasing Horizon Europe project applications	In the 2020 calls, approximately 70 stakeholders applied to the topics related to smart life and digital health, and 5 projects were supported. Until the end of 2023, it is aimed that a total of 100 stakeholders apply for the relevant project.

9. TÜSEB AND THE PRIVATE SECTOR

The Presidency of Health Institutes of Turkey (TÜSEB)[1] was established in December 2019 to serve our country and humanity in the field of health science and technologies, and to support planned and sustainable development. The Institute works to create the digital health ecosystem of our country by ensuring the organization of health data and integrating artificial intelligence technologies, wearable sensors, smart medical devices and robotic systems into diagnosis and treatment processes in order to increase the efficiency of health services and improve public health. Computer Aided Diagnostics is the field where artificial intelligence models are used most frequently in the field of health and have the most successful results. Within the Institute, projects are carried out in order to develop decision support systems that will facilitate diagnosis and assist health professionals, taking into account the needs of our country's health system and the demands from the field, and such research conducted by universities is supported.

Among the ongoing TÜSEB projects (https://www.tuseb.gov.tr/tuyze/en) for decision support systems that will facilitate the diagnosis of various diseases; Projects include estimation of heart attack risk from electrocardiography (ECG) data, digital analysis and cancer stage estimation in histopathology images, early-stage estimation of Alzheimer's disease with multi-modality data, estimation of blood glucose level from time series, and disease detection from lung computed tomography images. With the help of these developed artificial intelligence-based models, the diagnosis processes of various diseases will be made faster, the workload of health professionals will be reduced and the time cost will be reduced. One of the fields of activity of the institute is medical device design. In this context, among the projects carried out for medical device design; are the "Development of the electromyography device" and "Development of the breath analyzer" projects. The electromyography device project can be described as an indigenization study in the field of health. In the continuation of this project, studies will be carried out on devices that can measure different biological signals (EEG, EOG, etc.). It is aimed to support the diagnosis of various diseases by measuring the volatile organic components in human breath with the breath analyzer. In addition to all these projects, artificial intelligence and robotics-based projects such as smart robotic systems for physical therapy, motion support and monitoring systems are also planned**.**

In Türkiye, some companies deal with the development and production of health information technologies in the field of Smart Life and Health through different categories. Some examples of these companies are given in Figure 3.

[1]The promulgated call for proposals of projects can be seen here: https://www.tuseb.gov.tr/proje-destek/cagri-programlari/tumu

Figure 3. Turkiye market for AI tools and techniques

9. PROJECTS AND ACTIONS PLANNED TO BE CARRIED OUT FOR SMART LIVING AND SOCIAL WELL-BEING

The following projects demonstrated in the Table 3, are planned to be realized in the process coordinated by the Ministry of Industry and Technology.

Table 3. projects are planned by the Ministry of Industry and Technology

Critical Project	Description	Strategy	Stakeholders	Duration
Critical/Strategic Biotechnology Production Project	Domestic and new diagnostic kits, vaccines, recombinant technologies, blood components and derivatives, antibodies, antigens, antibiotics, immunomodulators, hormones, immunotherapy, probiotics, related raw materials and imported drugs will be produced locally.	Program/ Project Initiation	Ministry of Industry and Technology, TR Presidency Investment Office, Ministry of Health, TİTCK, TÜSEB	2021-2030
Autonomous National Health Technologies Evaluation Agency	The institution that does not make a policy and offers an autonomous scientific evaluation and technical opinion is recommended. (Ex. UK's NICE, France's HAS, Canada's CADTH)	Center Setup	TÜBİTAK, Ministry of Health (TİTCK, TÜSEB), SGK, Universities,	2021-2025
National -omics Platform	Genomics, transcriptomics, proteomics, and metabolomics are collectively referred to as omics technologies. Analyzers using Omiks technology can generate large data files every day. The data are then integrated so that a holistic understanding of their biological system can be obtained. Successful platforms can generate new views of cellular systems and diseases that will change the capabilities of the healthcare system.	Digital Transformation and Industry Move	TUBITAK, TUSEB	2022-2023

Transgenic Experimental Animal Production Center	A feasibility study will be conducted to develop transgenic mouse/rat platforms that allow the production of human antibodies to develop targeted therapeutics (mAb and small molecules) and new mAb-based drugs, and to open them up to researchers who want to develop drugs.	Virtual Center / Platforming	TÜBİTAK and TÜSEB, Ministry of Health, TİTCK, Universities, Private sector	2023-2030
Drug Discovery	A National Pharmaceutical Molecule Virtual Library will be created. The development of Drug Molecule Libraries has made it efficient to create new drugs through the detection of new molecules. Thus, drug molecule libraries have helped the development of the pharmaceutical industry, especially for premium drugs. (Ex. US NIH Molecular Libraries Initiative, Northwestern High Throughput Analysis Lab etc.)	Center Setup	TÜBİTAK, Ministry of Health, TİTCK, TÜSEB, Universities, Private sector	2028-2030

11. CONCLUSION

Considering the research in the literature and the investments made by the public and private sectors on these issues, it can be said that the contribution of artificial intelligence technologies to the life of people has become indisputable. The biggest benefit of this technology, which is thought to determine the future, is in the field of health. The development of artificial intelligence in this area promises such great potential that it not only facilitates and accelerates existing health services and business processes but also becomes a "preventive" factor with its early diagnosis and diagnosis capability thanks to its foresight. First of all, this means that deaths and diseases will decrease, life expectancy will be prolonged, and economies will be saved from huge costs.

This study focuses on cutting-edge solutions in the health sector that leverage advanced technologies to address complex challenges. One such technology is artificial intelligence (AI), which has garnered significant global investment for tackling health problems. By combining genes and nanotechnology with AI, we can unravel enigmatic aspects of the scientific world. It is worth highlighting the establishment of the Turkish Institute of Health Data Research and Artificial Intelligence Applications in March 2022, showcasing the recognition of the importance of AI in healthcare. Today, artificial intelligence-supported public health solutions, such as the Appointment and eNabız (H-MIS) application System, are widely used by millions of citizens, streamlining healthcare processes. Artificial intelligence also plays a crucial role in research, development, and clinical applications within the private sector. Particularly during the Covid-19 pandemic, AI has gained even more significance in drug development. Recent advancements include the exploration of "personalized" vaccine and drug techniques, which have garnered attention in recent weeks. In Turkey, health startups, including those focused on wellness and fitness applications, are actively employing AI. These startups utilize various sub-categories and techniques such as image processing, data analytics, optimization, and machine learning. Notably, many initiatives in the field of radiology employ AI to analyze imaging processes, generating "meaningful" analytical results that aid healthcare professionals in their decision-making and patient care.

As an outcome of this study, we tried to provide some suggestions on the usage of AI in the health sector to the Turkish government in the development of policy, strategic, and program levels.

1. *Prioritize AI for Social Good*: In line with the National AI Strategy, the government should prioritize the application of AI for social good, especially in the health sector. AI can play a vital role in addressing health-related challenges such as disease diagnosis, drug discovery, personalized medicine, and health monitoring.

2. *Establish a regulatory framework*: The use of super AI applications in healthcare should be subject to strict regulations and guidelines to ensure that they are developed and used ethically and safely. The regulatory framework should cover areas such as data privacy, security, accountability, and transparency.
3. *Conduct thorough risk assessments*: Before implementing super AI applications in healthcare, it is crucial to identify and assess the potential risks. This will enable healthcare organizations to take appropriate measures to mitigate these risks and ensure patient safety.
4. *Encourage Inspired Research Requirements:* The government should encourage research from the practical use of AI in the health sector. The focus should be on solving real-world problems and not just theoretical research.
5. *Foster Cross-disciplinary Teams and New Research Requirements*: The government should encourage cross-disciplinary research teams in the development and implementation of AI in the health sector. The teams should consist of experts from different fields, including computer science, medicine, public health, and ethics.
6. *Ensure Transparent Management Accountability*: The government should ensure that the resulting AI models in the health sector are interpretable, transparent, and accountable. This will help build public trust in the AI systems used in the health sector.
7. *Consider the Human-AI Boundary*: The government should consider the right human-AI interface, especially in the implementation of AI applications for social good. In areas with vulnerable populations, humans should have superior control insight knowledge, and the AI system should be subordinate to humans.
8. *Focus on Local Problems and Solutions:* The government should understand that many of the problems and solutions related to the implementation of AI in the health sector are uniquely local. The government should focus on solving local problems with locally relevant solutions.
9. *Ensure ethical AI development*: Healthcare organizations should ensure that the development of super AI applications is done ethically and in accordance with established ethical principles. This includes ensuring that the AI algorithms are transparent, explainable, and bias-free.
10. *Provide adequate training*: Healthcare professionals should receive adequate training on the use of super AI applications to ensure that they are used correctly and safely. This training should cover areas such as data management, privacy, security, and the ethical use of AI.
11. *Foster collaboration*: Collaboration between healthcare organizations, AI developers, and regulators can help to identify and mitigate risks associated with super AI applications in healthcare. This collaboration should be encouraged to ensure that the best practices are adopted for the safe and ethical use of super AI applications.
12. *Monitor and evaluate*: Healthcare organizations should continuously monitor and estimate with the help of internal audit bodies the use of super AI applications to identify any emerging risks and take necessary measures to mitigate them. This will help to ensure the safe and effective use of awesome AI applications in healthcare.

By taking these measures, healthcare organizations in Turkey can ensure that the use of super AI applications in healthcare is done safely and ethically, promoting social goodness and supporting the vision of smart life, Industry 4.0, and Society 5.0. In summary, the Turkish government should prioritize the application of AI for social good, encourage research from practical use, foster cross-disciplinary teams, ensure interpretability, transparency, and accountability, consider the human-AI boundary, and focus on local problems and solutions. By

doing so, the government can harness the power of AI to improve healthcare and the overall well-being of its citizens.

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