The significance of personalized medicine in healthcare services of the 21st century: a brief literature review

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ABSTRACT

In modern healthcare services, patient safety is a primary goal. With technological advancements, the complexity of healthcare services increases, which in turn creates increased pressure on health professionals during decision-making processes and can lead to errors worldwide. Communication gaps, human factors, patient-originated issues, technical failures, and inadequate policies have been identified as the main causes of medical errors. While research shows that errors stem from human nature and are inevitable, it is emphasized that it is possible to develop methods that enhance patient safety. Utilizing digital technologies to improve the quality and efficiency of healthcare services is a crucial strategy. Innovations such as wearable technologies, mobile devices, digital media-delivered education and consulting services, telehealth applications, 3D printers, clinical decision support systems, and implantable biosensors encompass advancements in the digital health field. This research aims to analyze the complex and dynamic structure of healthcare services in the 21st century, especially considering the opportunities presented by the integration of artificial intelligence and genomic data, within the scope of the relevant literature.

Keywords: Personalized medicine, 21st century, healthcare services, patient safety

According to the World Health Organization (WHO), the complexity of health systems can lead to patient harm, constituting a violation of patient safety [1]. Patients can face fatal consequences that become permanent if systematic measures are not taken to prevent errors in medical settings [2].

The Ministry of Health is the primary institution responsible for policy formation and the delivery of health services in Turkey [3]. It was established on May 3, 1920, following the inauguration of the Grand National Assembly of Turkey with Law No. 3. Despite the challenges of the war years from the 1920s to 1923, the state managed to provide health services through municipal and quarantine doctors, small health officials, 86 treatment facilities, 6,437 patient beds, 554 doctors, 69 pharmacists, 4 nurses, 560 health officers, and 136 midwives by 1946. The "First Ten-Year National Health Plan" introduced in 1946 never came into effect due to administrative changes. The continuation of this plan was the "National Health Program and Health Bank Studies" announced on December 8, 1954. This program aimed to increase the number of doctors and other health workers by dividing the country into seven health regions and estab-

lishing medical faculties in each. For example, following the medical faculties of Istanbul and Ankara Universities, Ege University Faculty of Medicine began training students in 1955. Compared to 3,020 doctors in 1950, there were 8,214 doctors by 2016 [4, 5]. The number of other health workers (nurses, midwives) also significantly increased. Along with the health services provided, the number of hospitals and health facilities grew, and there were decreases in the prevalence of some diseases and in infant mortality rates [6, 7]. Legislation regulating civil society groups, including the Turkish Medical Association, pharmacies, nursing, and the Turkish Pharmacists' Association, was also established, culminating in the Socialization of Health Services Law No. 224 in 1961. The true socialization of health began in 1963 and was fully implemented in 1983 with the help of state, district, and provincial hospitals [8].

In 1989, the decree-law established the "Ministry of Health and Social Assistance" replacing the "Health Ministry". Primary health services are provided by the Health Ministry through health centers, maternal and child health and family planning centers, tuberculosis dispensaries, malaria centers, and cancer fighting centers [9, 10]. Secondary and tertiary services are provided by the Health Ministry along with other public institutions, foundations, and commercialized health services. Notably, the Health Transformation Program in 2003 marked the ministry's shift to a "planning and supporting" role. The eight themes of the Health Transformation Program are as follows: (1) Planning and steering by the Ministry of Health, (2) An all-encompassing general health insurance system, (3) Accessible, affordable, and welcoming health services (to support system institutions with education and science, Quality and accreditation for competent and effective health services, Institutional structuring in rational drug and material management), (4) Highly motivated health workforce equipped with knowledge and skills, (5) Education and science to support system institutions, (6) Quality and accreditation for competent and effective health services, (7) Institutional structuring in rational drug and material management, (8) Effective information access in decision-making: Health information system. In 2007, three additional headings were added: (1) Health improvement and healthy life programs for a better future, (2) multi-sectoral health responsibility for activating stakeholders

and inter-sectoral collaboration, (3) Transboundary health services to enhance the country's strength internationally [11].

Personalized writing techniques can avoid medical errors and enhance patient safety. Personalized medicine practices can be seen as a significant advancement in preventive and evidence-based health systems. Most medical procedures today are designed for the average person accepted by most of the population. However, each person is unique with a different genetic makeup, which explains why some patients respond positively to a treatment regimen that fails in others. Researchers have identified genetic variations in patients' responses to targeted therapies and developed diagnostic tests based on genetic or other molecular causes. This innovative approach to disease prevention and treatment focuses on tailoring health services to everyone's genetic makeup, environmental factors, and personal characteristics [12, 13].

HEALTHCARE SERVICES IN THE 21ST CENTURY

Since the 1960s, genetics has become an integral part of the health system and now plays a primary role in the prevention and treatment of common chronic diseases such as cancer and heart disease [14]. Renato Dulbecco realized in 1985 that sequencing the human genome was essential for advancing cancer research [15]. The Human Genome Project was initiated in 1990, with its first draft published in 2001 and the final draft in 2003 [16]. The concept of personalized medicine was first introduced to the public in a 1999 Wall Street Journal article titled "The New Age of Personalized Medicine: Targeting Drugs to Unique Genetic Profiles." This article discussed how even the best treatments in contemporary pharmacotherapy were effective in only 50-70% of patients, indicating that this method was acceptable for all individuals [16, 17].

Developments in biomedical, social, technological, and economic disciplines are believed to be the driving force behind personalized medicine. This strategy is based on finding genetic, epigenomic, and clinical information, including methods to determine how an individual's genomic profile makes them susceptible to certain diseases [18].

Standard treatments like chemotherapy and radio-

therapy do not have the same effect across all patient populations due to the heterogeneity of diseases. It is believed that personalized medical practices, by revealing individual biological distinctions, will significantly contribute to the detection and treatment of cancer [19]. The identification of individual risk factors based on genetic or physiological biomarkers for cardiovascular diseases such as atherosclerosis, heart failure, and hypertension, and the development of personalized medicine techniques are crucial for early intervention [20]. Diabetes mellitus is characterized by significant heterogeneity in genetic risk factors, underlying pathogenic mechanisms, and clinical symptoms, making it a complex and diverse disease of the endocrine system. However, individual characteristics that can influence clinical outcomes and therapeutic responses in patients with type 2 diabetes are rarely considered, and comparable treatment approaches are often utilized [21].

Personalized drug applications in managing disorders where genetic and environmental factors play a significant role can facilitate the development of targeted treatments [22, 23].

Another promising area for personalized medicine applications is dermatological diseases, which are among the most common and preventable diseases affecting millions. Personalized medicine practices can reduce side effects that may jeopardize patient safety, increase patient compliance, and provide economic benefits through the prevention, early diagnosis, and treatment processes of dermatological disorders [13]. Pain management is a very important aspect of patient safety that is considered. While everyone's pain threshold varies, basic pain management approaches are predominantly used worldwide. A study in the United States on post-surgical pain treatment suggested the use of personalized methods to create individualized pain management treatment plans based on each patient's genetic coding for analgesic metabolism and pain sensitivity [24].

Another area of interest in personalized medicine for patient safety is the development of specific protective and treatment techniques for allergy and asthma patients [25]. The synthesis of specific Immunoglobulin E (IgE) is identified as a feature of an allergic response defined by exposure to allergens and the immunological reactions to these antigens [26]. Allergic diseases, being among the most common dis-

eases worldwide and having rapidly increased in prevalence to date, are likened to a black hole consuming resources in the medical community. Each allergic patient has unique characteristics managed by clinical history, response to treatment, cellular mechanisms, and hereditary and epigenetic control by the environment. Key terms in this field aiming to improve patient care and create better prevention and treatment strategies through phenotyping, genotyping, therapy, and biomarkers include characterizing unique features of allergy phenotypes to develop targeted allergen immunotherapy, which can improve patient safety, enhance quality of life, and provide financial benefits [27, 28].

Personalized drug procedures, although now expensive for individual patients, have the potential to minimize long-term expenditures by providing prevention methods that reduce morbidity, more accurate diagnoses, and more successful treatment regimens. Thus, scientific evidence about disease pathophysiology and genetic risk factors can be used to design a more efficient drug production method and potentially provide greater benefits to the pharmaceutical and medical device industries. Additionally, personalized medicine facilitates the provision of excellent care with highly reliable diagnostic and treatment options, enhances patient safety, and increases patient satisfaction [13, 17].

Achieving desired outcomes in personalized health applications requires successful collaboration with stakeholders. Primary stakeholders in this endeavor include service providers, service users, governments, academia, biotechnology firms, individuals/institutions working in data mining, patients, authorities, payers, and health professionals with authority over ethical regulations and legal requirements [29]. Personalized medicine practices have the potential to enhance patients' quality of life, life expectancy, and the efficient use of time and money however, it is a politically complex issue [30].

Health is a policy issue affecting numerous fields including science, technology, economics, law, and public administration. Research in Europe and the United States highlights the importance of government funding for research in this field [31,32]. Identifying protective measures for individuals at risk for specific diseases and determining early intervention methods based on variables related to disease progression at the

community level are additional significant contributions this technology can make to future health policies [33, 34].

One of the benefits of next-generation technologies for patient safety is the provision of a large amount of monitoring-based data. By analyzing this data, future health policy decisions can be informed. Future applications of personalized medicine will provide new sources of information about diagnostic and treatment options, allowing patients to have more control over their health in various ways; reliable information will be easily accessible; multidisciplinary clinical decision support systems will be used more effectively; education for health professionals will be enhanced, and resources will be more effectively used for the benefit of the community. The more precise, reliable, systematic use of data flows is expected to lay the groundwork for the emergence of new professions in the health services sector [35].

In terms of patient safety, personalized medicine methods have made many positive contributions to health systems, but there are also ethical and legal concerns. One of these concerns is the cost-benefit ratio; the question is whether the expected benefits of these highly costly technologies will be realized in practice.In a world where demand is unlimited, resources are limited, and the costs of health services are rising, whether investing in personalized medicine is a cost-effective strategy is debatable [36, 37]. Equal and equitable access to these technologies, the appropriateness of revealing individuals' genetic sequences in a health sector with intense information asymmetry in terms of autonomy and privacy, and the accuracy and reliability of technologies used in the field of personalized medicine are among the other ethical issues under discussion.

METHODS

The methodology of this research has been designated as a literature review. Accordingly, the study is designed to thoroughly examine existing studies and research on precision medicine, artificial intelligence, and genomic data relevant to the objectives of the research. This process will utilize scientific databases such as PubMed, Scopus, Web of Science, and Google Scholar. Keywords include "precision medicine," "artificial intelligence in healthcare," and "genomic data and medicine." Selected articles are limited to those published in the last ten years. Accordingly, the findings section is subdivided based on the data considered.

RESULTS

Precision Medicine
The broad goal of precision medicine is to tailor treatments, drug types, and dosages to each individual while also adapting personal prevention methods, thereby enhancing patient safety [38]. When considering patient safety, issues such as drug ineffectiveness, side effects, drug interactions, and patient dissatisfaction might necessitate trial and error in treatment adjustments, potentially leading to delayed correct treatment and disease progression [39, 40]. For diseases with high burdens and mortality rates such as cancer, diabetes, neurodegenerative diseases, systemic lupus erythematosus, and rheumatoid arthritis, as well as less common diseases like infectious meningitis, encephalitis, and vasculitis, precision medicine technologies hold promise for early diagnosis and treatment [41, 42]. For example, cancer, considered a leading cause of death globally, is expected to kill approximately 35 million people by 2050, but if diagnosed early, can be effectively treated [43].

Genomic Data and Medicine
Standard treatments like chemotherapy and radiotherapy do not have uniform effects across all patient populations due to the heterogeneity of diseases. Precision medical practices that reveal individual biological distinctions are believed to significantly contribute to cancer detection and treatment [44-45]. The identification of individual risk factors based on genetic or physiological biomarkers is crucial for early intervention in cardiovascular diseases such as atherosclerosis, heart failure, and hypertension [46]. Diabetes mellitus, characterized by significant heterogeneity in genetic risk factors, underlying pathogenic mechanisms, and clinical symptoms, presents a complex and varied disease of the endocrine system. However, individual characteristics that may influence clinical outcomes and therapeutic responses in patients with type 2 diabetes are often overlooked, with frequent reliance on

comparable treatment approaches [47].

In disorders where genetic and environmental factors play a significant role, personalized drug applications can facilitate the development of targeted treatments [48]. Another promising area for precision medicine applications is dermatological diseases, which are among the most common and preventable diseases affecting millions. Personalized medicine practices can reduce side effects that may jeopardize patient safety, enhance patient compliance, and provide economic benefits through prevention, early diagnosis, and treatment processes of dermatological disorders [49].

Pain Management

Pain management is a critical aspect of patient safety. Although each individual's pain threshold varies, basic pain management approaches are predominantly used worldwide. In the United States, a study on post-surgical pain treatment recommended the use of precision methods to create individualized pain management treatment plans based on each patient's genetic coding for analgesic metabolism and pain sensitivity [50, 51].

Allergy and Asthma

Another area of interest in personalized medicine for patient safety is the development of specific protective and treatment techniques for allergy and asthma patients. The synthesis of specific Immunoglobulin E (IgE) is a feature of an allergic response defined by exposure to allergens and the resulting immunological reactions [52].

Artificial Intelligence and Precision Medicine Health Services

While personalized drug procedures are now expensive for individual patients, they hold the potential to minimize long-term expenses by providing prevention methods that reduce morbidity, more accurate diagnoses, and more successful treatment regimes. Thus, scientific evidence about disease pathophysiology and genetic risk factors can be used to design a more efficient drug production method and potentially provide greater benefits to the pharmaceutical and medical device industries in Fig. 1. Additionally, precision medicine facilitates the provision of excellent care with highly reliable diagnostic and treatment options, enhances patient safety, and increases patient satisfaction [53].
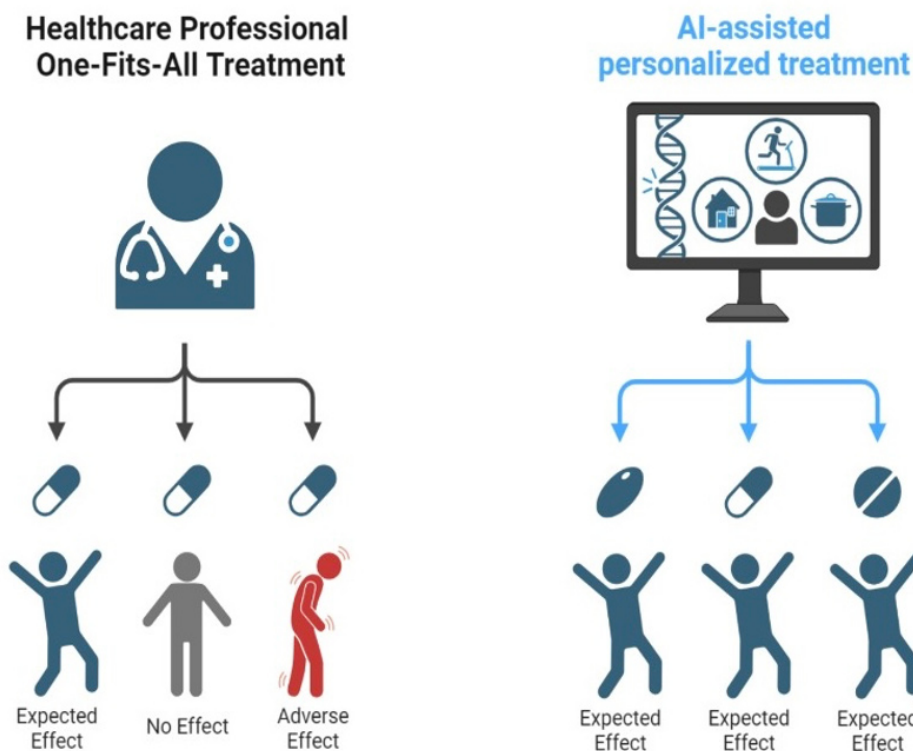

Fig. 1. Personalized Medicine AI vs Traditional Techniques (Created with BioRender.com).

Achieving desired outcomes in personalized health applications requires successful collaboration with stakeholders. Primary stakeholders in this endeavor include service providers, service users, governments, academia, biotechnology firms, individuals/institutions working in data mining, patients, authorities, payers, and health professionals with authority over ethical regulations and legal requirements. Precision medicine practices have the potential to enhance patients' quality of life, life expectancy, and the efficient use of time and money; however, it is a politically complex issue [54, 55].

DISCUSSION

Health policy impacts numerous fields including health, science and technology, economics, law, and public administration. Studies in Europe and the United States underscore the importance of government funding for research in this area [31, 32]. Identifying protective measures for individuals at risk for specific diseases and determining early intervention methods based on community-level disease progression variables are additional significant contributions this technology can make to future health policies [56].

One of the benefits of new-generation technologies in terms of patient safety is that they provide large amounts of monitoring data. Analyzing this data allows informed decisions about future healthcare policies to be made. Future applications of precision medicine will enable patients to take greater control over their health by providing new sources of information about diagnosis and treatment options. In addition, easy access to reliable information sources will be provided, multidisciplinary clinical decision support systems will be used more effectively, the training of healthcare professionals will be contributed and resources will be used more efficiently for the benefit of society. More precise, reliable, and systematic use of data streams will facilitate the emergence of new professions in the healthcare sector [24, 48].

Primary healthcare services are defined as services provided to individuals and families in the community universally accessible, with full participation, and at a cost that the community and country can afford. They are a vital aspect of both the country's health system and the overall social and economic development of the population [57].

As a result of market liberalization, private organizations in Turkey, as in the rest of the world, provide health services under state supervision. The competitive nature of markets necessitates various marketing strategies. The fact that health care is considered a human right makes it inevitable to criticize this situation. Due to the irreparable, irretrievable, and unacceptable nature of errors in service delivery, and the primary responsibility of health professionals, ethical rules make it imperative to distinguish patients from other consumers. These factors determine the health services provided. The provision of services that directly affect human health should be the basis of planned and carefully implemented marketing efforts [58].

CONCLUSION

Health is currently one of the sectors most affected by the digital revolution. Thanks to digital health technologies, there is a shift from traditional hospital-based, treatment-focused approaches to individual-centered preventive approaches. Soon, personalized medical applications will play a key role in preventing, diagnosing, and treating diseases in terms of patient safety.

Personalized medication applications are particularly promising for various unresolved, uncommon, autoimmune, and neurodegenerative disorders. Considering the generational and professional training differences between different patient demographics and health professionals in the community, assessing the challenges that might be encountered in technology usage is essential for training health professionals who will ensure patient safety and planning accordingly. It is crucial for countries to emphasize these concerns in their health strategies to improve public health and reduce costs over time.

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