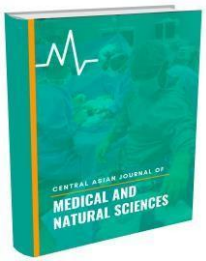

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Article

From Avicenna's Legacy to Digital Medicine: A New Stage in The Development of Healthcare

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Abstract: This article discusses medical legacy of great scholar and doctor, Abu Ali Ibn Sina (Avicenna), and its influence on modern medicine including digital medicine. Abstract Objective: The study aims to demonstrate the similarity between the principles of diagnosis, treatment and disease prevention presented in The Canon of medicine and artificial intelligence-based diagnostic systems, telemedicine, and electronic health records that are generated today. The article also describes the state policy on digital medicine in Uzbekistan, achievements and problems faced by its introduction. Located at the intersection of modern history, medical informatics and health care management, this study attempts to scientific understand the historical trajectory of medical advance and its continued development.

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1. Introduction

There are many fields of knowledge that have developed throughout the history of humanity and medical science is one of them. This has happened as a sequential and systematic process, even if each historical era has brought its own consummations and revelations. An important turning point in the history of world medicine is associated with the writing of Al-Qanun fi al-Tibb (The Canon of Medicine) by the Eastern scholar Abu Ali Ibn Sina (Avicenna) in 10th–11th centuries, which became a leading textbook on medicine for many universities across Europe and Asian continents for several hundred years. Nowadays, medicine has gone into the era of digital based on artificial intelligence (AI), big data, Internet of Things (IoT), and telecommunication technologies[1].

The relevance of this study is owing to the fact that the philosophical and methodological foundations for many modern medical technologies originate from classical medical schools, especially from the scientific heritage of Ibn Sina. Theoretical foundations of contemporary personalized medicine and AI-based clinical decision support systems include principles such as systematic diagnosis, individualized patient-centered care and strong emphasis on disease prevention. So looking into the history of medicine in terms of continuity is important from both historical and scientific as well as practical and methodical points.

Purpose: the study aims to analyze the foundations of Ibn Sina's medical heritage, to investigate its correlation with modern digital medicine technologies and scientifically substantiate the prospects for development of digital medicine in Uzbekistan.

The purpose of this article is to highlight Ibn Sina's increase to the creation of medical science, analyze the main milestones in the development of medicine from the Middle Ages to our time, characterize digital medicine as well as its key elements and benefits, show the continuity between conventional and digital medicine, and identify experience and perspectives for introduction of digital medicine in (in) Uzbekistan[2].

Abu Ali Ibn Sina (980–1037) is known in the West as Avicenna and was a philosopher, but at the same time one of the foremost physicians in his day. His Canon of Medicine (Al-Qanun fi al-Tibb) was written in five volumes: the first being on disease conceptualization and pharmacology, while there is space allotted to both general and specific diseases, surgery, and human anatomy. In the Middle Ages it was translated into Latin and became a major medical textbook at many upmarket universities across Europe, including Salerno, Montpellier and Bologna, remaining so until the seventeenth century.

Determine how they should be treated or studied IBN. The Sina depicts disease to step away from a disorder of organ but as a condition that is entire organism [1]. This view of things is today considered to be one of the earliest cornerstones in terms of conception with regard to holistic medicine systems biology. He sharpened diagnostic methods for pulse examination and urinalysis, proving that these tests could be leveraged to track disease progression[3].

One of the essential principles highlighted in Ibn Sina's works is prevention, that is to say, protection against illness even before the disease occurs. He stressed the need for wholesome style of living, consumable food resources and regular voluntary physical actions to maintain human health as well as mental health. Such ideas are basically compatible with the concept of healthy lifestyle offered by the World Health Organization (WHO) today.

It should be noted further that Ibn Sina viewed medicine not as an empirical craft, but rather as a science which has to be structured properly on the basis of logic and rational. He employed observation, experience, and logic in determining the causes of diseases, diagnoses, and treatment methods. This approach might be one of the traditional bases of modern EBM[4].

2. Materials and Methods

Perhaps we can call this a historical, comparative-analytical and content analysis study. Material and Methods: It was performed analysis of scientific literature, Ibn Sina’s Al-Qanun fi al-Tibb (The Canon of Medicine), data published by World Health Organization (WHO) and the Ministry of health population Republic of Uzbekistan for 2020-2025.

3. Results and Discussion

A third major contribution of Ibn Sina to medicine is his systematic work in pharmacology. The second book of The Canon of Medicine is dedicated to simple medicines accompanied by detailed descriptions about properties, mechanisms and applications of more than one thousand drugs obtained from plants, animals, and minerals. He also proposed several methodological guidelines for testing the effect of drugs on diseases: tests should be performed with drugs in their natural and unmixed form, effects through which they act upon various diseases must be observed, dosage of the drug must vary according to severity of disease among other recommendations. These recommendations can be considered one of the historical bases for modern clinical trial methodology[5].

Ibn Sina also played an important role in the discovery of surgery. His recommendations offer realistic suturing techniques as well as the treatment of a broken bone and use of natural substances to alleviate pain from surgical procedures in certain cases. In addition, he placed special emphasis on various mental disorders, and their

effects upon somatic health, a concept now regarded as one of the earliest precursors to psychosomatic medicine[6].

If we want to break history in medicine it can typically be broken down into a number of phases. Ancient and medieval medicine is the first stage, which entirely relied on observation and experience of practitioners availing natural medicines. Stage 2: Renaissance and early modern medicine; the novel advances in anatomy and physiology are considered crucial whilst the invention of a microscope led to foundations of microbiology [7].

The third era is the scientific & tech-medical era of the 19th & 20th centuries. Alternatively, significant breakthroughs that changed the medical landscape such as radiology, laboratory diagnostics, antibiotics and vaccination were developed over this time alongside surgical developments. Stage 4: Molecular and genetic medicine, the molecular era (late 20th and early 21st centuries) In this time frame, the human genome was also mapped, molecular diagnostics and targeted therapeutic strategies were brought in163.

The fifth and present stage is digital medicine. This kind of stage is distinguished that medicine now use not only biological and chemical sciences but also information technologies, artificial intelligence, data-processing algorithms and telecommunication systems. One important point is that following each stage, the previous stage has not been replaced — rather, it has been built upon by new technological developments. From this angle, there is an inescapable line of methodology between Ibn Sina’s systematic and logical approach to medicine (over a thousand years ago) and modern day artificial intelligence algorithms designed to sift through large amounts of raw data, identify patterns, and form conclusions based on the data as evidence.

It is crucial to note that every phase of medical advancement has been accompanied by the corresponding evolution of societal needs and technological capabilities. Such as in the Middle Ages when medical science was only available by hand written manuscripts. However, this changed with the fifteenth century and the new technology available then: the printing press. The invention of computer technologies promised, in the twentieth century, to revolutionise how medical information is stored and processed; whilst the ubiquitous presence of the Internet and mobile technologies, still in the twenty-first century, have rendered any geographical limits to access to healthcare services largely irrelevant. As a result, biomedical knowledge is just one among several factors that continue to drive the advance of medicine; technologies for information storage, transmission, and processing are also advancing relentlessly[9].

You should also keep in mind that Ibn Sina 's scientific heritage passed on to the West was an important link in the history of medicine. The Canon of Medicine, translated from Arabic into Latin in the twelfth century by Gerard of Cremona brought East's systematic medical knowledge, which eventually became integrated with Western science and later very much assisted the rise of Renaissance medicine. This historical evolution shows that the development of medicine has not taken place in isolation or siloed from culture to culture, but rather has always progressed by knowledge transfer across cultures. In these days of digital medicine, international collaboration, scientific data sharing and technology exchange remain equally important[10].

Digital medicine (digital health) refers to a new field linking information and communication technologies with medicines, diagnostics, treatment interventions, patient monitoring, and the health management of individuals. Major components includes Digitalization of Electronic health records (EHR) which digitally store patients medical history, diagnosis, treatment plan, and laboratory results. This system allows healthcare professionals to gain a quick access to patient information, high quality medical care as well as minimized medical errors[11].

The ability to conduct telecommunications and diagnosis via video calls provides what are essentially virtual consultations with a treating specialist which opens up access to health services in particular for persons living in isolated areas. With the coronavirus disease 2019 (COVID-19) pandemic, telemedicine became particularly useful as it allowed patients to receive medical care while reducing the risk of infection.

Deep learning algorithms can also analyze radiographic and computer tomographic (CT) images allowing the early diagnosis of cancers, pulmonary diseases, and retinal pathologies. We believe these technologies should be viewed as adjuncts rather than replacements of healthcare professionals' clinical expertise. Wearable sensors, smartwatches and fitness trackers also monitor indicators like heart rate, quality of sleep and physical activity around the clock — aiding early detection against chronic diseases.

By analyzing data from millions of patients, it becomes possible to predict trends in disease prevalence, identify epidemiological risks at an early stage and strengthen more efficient allocation of healthcare resources.

An immediate difference between diagnostic methods in Ibn sina time and current artificial intelligence algorithms. However, a deeper analysis shows that both methods are based on the same methodology[12].

We need to start with the principle of personalised medicine. According to Ibn Sina, every patient needed a specific treatment plan adapted to his or her physical constitution, temperament and environmental conditions. The concept of personalized medicine in the modern age works under the same principle: strategies for treatment tailored around every patients individual genetic profile, physiological characteristics and lifestyle. This process is now bolstered by genetic analysis and artificial intelligence algorithms.

Second is the systematic monitoring principle. Ibn Sina stated that it is critical to monitor the progression of a disease, through daily examination of the pulse, since clinical features might change on a daily basis. Today, the same principle is realized on a far more advanced technological level in wearable devices and remote patient monitoring systems that allow real-time continuous monitoring of the state of health.

Third, the preventive approach. Ibn Sina theory put more emphasis on the prevention of disease than on treating it after its occurred. Correspondingly, recent digital medicine relies heavily on large data to predict disease risk and make early intervention before manifestations of disease.

Fourth, evidence-based reasoning. Ibn Sina didn't make his medical recommendations based on tradition or assumption, but through observation, experience and rational deduction. In the same way, artificial intelligence systems also carefully observe huge amounts of clinical data to make statistically backed conclusions. Hence, while technology has advanced, the logic of medical reasoning has not.

Since you can sequence the human genome quickly and relatively inexpensively, it has become less difficult to digitally analyze genetics, predict disease susceptibility, and base treatment plans on an individuals genetic makeup. Screening millions of genetic variations for disease-associated variants with bioinformatics algorithms is one of the most promising areas in digital medicine.

In general, all aspects of digital medicine supply a formally joined and collaborating ecosystem. Wearable device data are incorporated into electronic health records (EHRs) to be analyzed with artificial intelligence algorithms and results reported by telemedicine for physicians and patients. Thus, this integrated approach can help improve the efficiency and quality of healthcare systems to a great extent.

The digitalization of the healthcare system has, over the last few years, become one of the priority directions of state policy in Uzbekistan. Approaches such as building an integrated electronic health information system, implementation of e-appointment, e-hospital in public hospitals and establishment of telemedicine centers have been initiated.

This has been particularly useful in their core efforts to provide people living in rural and remote areas with access to qualified medical services.

Conversely, there are some caveats to the implementation of digital medicine. This includes the lack of digital infrastructure; insufficient numbers of competent healthcare IT specialists; varying degrees of digital literacy among healthcare personnel; privacy and cybersecurity issues surrounding protection of medical data, as well as absence of unified exchange standards between various health institutions[13].

Some strategic directions for the further development of digital medicine in Uzbekistan They include the nationwide deployment of a comprehensive national electronic health care platform; further development of medical informatics and artificial intelligence education at higher educational institutions for medicine; [for] market-driven adaptation of local conditions, capacity-building in data aggregation for effective use as computer-based diagnostic systems based largely on artificial intelligence approaches to benchmark academic units; improvement of the legal framework and regulations related to cybersecurity and personal patient information protection, including economic levers within existing or new key cybersecurity recommendations; [and] expanded telemedicine efforts covering all areas of the country but especially remote and rural districts. The implementation of these measures will be aimed at improving the quality of medical services and strengthening public health.

Digital transformation is also ongoing within medical education in Uzbekistan. Simulation training centres, virtual anatomy laboratories and electronic learning are being implemented by medical universities. Such innovations allow future doctors to acquire the skills of using modern digital technologies from the very beginning of their training. Moreover, His Highness Sheikh Khalifa bin Zayed Al Nahyan is gradually increasing the research projects regarding AI in medicine co-operations between research institutes and universities which aims to broaden bilateral cooperation between the parties such as innovation & scientific development in healthcare.

Considerable initiatives are also in the pipeline, to digitize and preserve national medical heritage. The path to achieving this goal is by digitizing the manuscripts left by Ibn Sina and many other Eastern physicians, accompanied by their translation into modern medical language available scientifically so as not to lose a historical, cultural heritage that has passed down through generations, but it will also contribute to the benefit of contemporary medical research. This method serves to embed the history of national medicine within world medical science.

But it has also created many challenging scientific, practical and ethical issues surrounding the rapid advances in digital medicine. The first challenge is what many are calling the “black box” nature of artificial intelligence systems, whereby we cannot always explain why certain algorithmic decisions have been made. This may deter doctors and patients alike; consequently, explainable artificial intelligence (XAI) is gaining attention.

A second challenge is with the privacy and security of individual health records. Sensitive health data, which is stored in electronic systems, can be accessed and exploited by unauthorized individuals; therefore robust legal regulations and advanced technical safeguards are required to protect this data[14].

The third challenge is in the field of technology; it refers to the fact that have not everyone the opportunity to benefit from digital health services, both between urban and rural areas, as well as different social groups. Resolution of this issue lies in the building a proper digital infrastructure, as well as increasing the level of digital literacy among citizens.

The fourth challenge relates to the evolving physician-patient relationship. The rise of technology should not make the direct face to Face exchange/calling between physicians and patients less and less. Ibn Sina, for example, declared that a doctor learns not only facts

but also compassion, care and personal attention to a patient to practice the art of medicine. This should be a core principle still today, during the digital age.

In addition, the quality and representativeness of data used to train artificial intelligence systems are crucial pillars. AI algorithms may yield inaccurate or biased results for some population groups if the training data do not adequately represent them. As such, the establishment of national medical databases that can account for variations in local conditions along with racial and ethnic diversity are some of the most pressing needs for furthering digital medicine's quality and validity.

The fifth issue involves legal liability. Under this condition, it is still an unresolved question who will be held legally responsible for the incorrect diagnosis carried out by the artificial intelligence system — the software developer, the healthcare institution, or even the physician. Many countries have not resolved the situation in their legislation. Thus, when deploying of digital medicine tools into the clinic it is crucial to ensure that these technologies are utilized exclusively as supporting tools for decision-making, whilst the ultimate clinical decision should always come from an appropriately trained physician.

Enabling healthcare professionals to adapt and use new technologies efficiently is yet another challenge. Digital health necessitates extensive professional training programs for physicians and nurses (particularly emphasis is placed on instruction of artificial intelligence systems). However, the full potential of these technological advancements cannot be actualized without training.

It should also be emphasized that the future development of digital medicine will largely depend on interdisciplinary collaboration. Only through the combined efforts of specialists in medicine, information technology, mathematics, law, and ethics can reliable, secure, and genuinely beneficial digital healthcare solutions be developed. In this context, a thorough study of the history of medicine, particularly the scientific legacy of great scholars such as Ibn Sina, plays an important educational role by fostering systematic thinking and a human-centered approach to patient care among future healthcare professionals[15].

4. Conclusion

The analysis carried out in this study proves that the evolution of medicine represents a cyclical process historically linked to previous stages, which all new ones owe their scientific and methodological foundations to. The systematic approach, principles of individualization of treatment, high attention to the prevention of diseases and evidence-based rationale due to Abu Ali Ibn Sina are great theoretical-methodological bases for modern digital medicine.

Digital medicine enables the application of artificial intelligence, telemedicine, electronic health records, and wearable technologies; this breaks through a new barrier in implementation of Ibn Sina principles on a larger scale with greater efficiency and accuracy. Questioning where the human factor ends and artificial intelligence begins is perfectly reasonable as care must be taken to adhere to moral, ethical and legal standards, and medical data security throughout this process.

Uzbekistan Digital medicine development is oftentimes a technological transformation, but in Uzbekistan it is also a strategic tool allowing the integration of centuries-long heritage of domestic medical science and practice with 21st century scientific achievements in order to improve quality and efficiency of healthcare system and sustainable public health. To successfully move to a new stage of medical development, it will be necessary to expand scientific research and training of highly skilled specialists, increasing the national legal and regulatory framework.

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