A Study on the Communication Ecosystem of TCM Health Big Data Based on Cloud Computing

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1. Introduction

International competition has increased as the process of global economic integration has been accelerated, and science and technology have become increasingly vital in economic progress. Due to the needs of the time and the pressure of survival, numerous scientific research organizations and industries have increased scientific research and innovation with policy encouragement and financial assistance from governments of various nations [1]. Science and technology research and application disciplines have been substantially broadened, and technological innovation has sprung up. It is important to optimize the technological research and developmental capabilities of producing high-quality Chinese medicine to improve the status of China’s traditional Chinese medicine industry. Advanced TCM technology research and development skills are the basis and foundation for the manufacturing of high-quality TCM [2].

With the rapid development of computers and the Internet, human society is increasingly facing information shocks and surviving under a large number of data packages. Since 2009, “big data” has gradually become a popular vocabulary for human life [3]. With the popularization and application of Internet information technology, big data thinking modes and action modes have penetrated various industries, business functions, and daily life. With the improvement of human ability to process information, big data has brought many advances to society and achieved remarkable results, and how to deal with the processing, management, and control of massive data has become an urgent problem [4]. In recent years, the value of data extraction has been continuously improved, especially with the development of artificial intelligence (AI), which brings about broad prospects and imagination to the application of big data. The development of technology has brought about social progress, and the application of big data has enriched
people’s lives. For businesses, big data can derive hidden business logic, improve business processes, work efficiency, and service quality, and optimize business decisions by collating and mining data. For the medical industry, big data can help summarize and analyze the strengths and weaknesses of existing medical systems to improve processes [5].

TCM, unlike western medicine, has a limited number of linked fields. Its practitioners must learn to employ current scientific and technical advances flexibly to break through the fierce competition. Yu et al. [6] argued that big data is analogous to TCM informatics. Big data technology may be employed to support the growth of traditional Chinese medicine informatics, allowing useful data to be located and accessed in vast amounts of data to benefit traditional Chinese medicine research. To cope with the “whole data” of Chinese medicine, Cui [7] used the related techniques of “big data” and the ontology-based Chinese medicine language system to uncover and anticipate the technical knowledge of traditional Chinese medicine in the prevention of disease. Through the implementation of data mining methods to efficiently recognize the characteristics and laws of traditional Chinese medicine treatment of lung cancer, Fan [8] and Liu [9] have successfully identified the characteristics and laws of TCM treatment of the disease. Huang [10] thinks that, with big data technologies, traditional Chinese medicine’s hidden, individualized, and empirical information may be transformed into unstructured data, assisting in the modernization of Chinese medicine.

This study attempts to introduce the operational framework of big data into the field of TCM cultural communication and health management and elaborate mathematically and scientifically on the aspects of TCM diagnosis, TCM syndrome research, TCM clinical experience, and TCM clinical research. Then TCM Health Big Data Ecosystem is proposed. Under the perspective of TCM Health Big Data Ecosystem, the operation logic, mode, and problems of TCM Health Big Data, management information communication, and subsequent application forms are analyzed. Using different application scenarios of TCM Health Big Data, AI, and data visualization models, the attempt is made to bring innovative ideas to TCM big data applications, improve the productivity of TCM, and build competitive application models.

The rest of the manuscript is organized as follows: Section 2 describes various aspects of big data and TCM. Section 3 illustrates the TCM Health Big Data Ecosystem. Section 4 provides an overview of the construction of the TCM Big Data Ecosystem and Section 5 is the conclusion.

2. Development of Big Data Technology

2.1. Big Data and Operation Framework. With the continuous development of big data applications, the definition of big data in academic circles has always been difficult to form a unified conclusion and presents a diversified development trend. The insightful Nature magazine published a special issue on the topic of big data as early as 2008 [11]. In the book “Big Data: A Revolution That Will Transform How We Live, Work, and Think” written by Mayer and Cukier, big data is defined as “something that people can do based on large-scale data, and these things cannot be completed based on small-scale data” [12]. The authors in [13] consider that big data is a huge, high-growth, and dissimilar information asset, which requires new processing models with greater decision-making, insight, and process optimization capabilities. Big data frameworks refer to distributed processing and analysis software libraries and algorithms for solving big data problems between computing unit clusters [14].

Despite the variety in definitions of big data, reaching an agreement is challenging. However, as time passes and information technology advances, the application value of big data becomes more apparent. The 4V dimension proposed by Mayer and Cukier [12] is currently recognized as big data characteristics: Volume, Velocity, Variety, and Value.

(i) Volume: Data is measured with computer units; the starting unit of big data measurement is at least P (1000th T), E (1 millionth T), or Z (1 billionth T).

(ii) Variety: Data includes audio, video, pictures, text, geographic information, and many other data types. So higher data processing capabilities are required.

(iii) Value: The analysis and mining of big data will play a revolutionary role in the development of many fields of society, especially in medical research and development, disease diagnosis and treatment, public health management, and health management.

(iv) Velocity: Data is rapidly generated in a dynamic form; high data processing speed and timeliness are required, technically speeding up data processing through cloud platforms and cloud computing.

Traditional software cannot extract, store, search, distribute, analyze, or process big data, since it comprises huge volumes of data. To get information and insights from a large and complex set of data, a data processing framework must be established to standardize big data collection, processing, analysis, and application.

The processing framework of big data should use the advancement of information technology and computing methods and use hardware devices to aggregate data in different formats and different fields to form a unified data source. Social value and economic benefits can be generated and the future can be predicted through data cleaning, mining, analysis, and application. The direction of event development can be intervened in or changed through AI. The entire process lives its unique operating framework and logic.

The era of massive data provides unprecedented space and potential for humans to gain deep and comprehensive insights and poses new challenges to the human ability to harness data. With the rapid development of technology, the transformation of the era is coming.

2.2. Big Data National Strategy. Big data opens the door to social revolution. Data searching and analyzing can help collect valuable information from massive data. With the help of AI technology, it can accurately predict the unknown
trend, control the direction of the future, and lead at the front of development of the times. Vigorously developing the big data industry has become a global consensus. All countries in the world are rapidly chasing the wave of the era brought by big data and fully promoting the development of big data technology [15].

On March 29, 2012, the United States firstly proposed big data as one of the country’s important strategic resources and officially released “Big Data Across the Federal Government” [16]. In June 2013, the Abe Cabinet issued the “Creation of the Most Advanced IT National Declaration,” which outlined a new IT national policy based on the creation of Open Public Big Data and suggested that Japan has become the world’s most advanced information technology society [17]. On October 31, 2013, the UK government issued “Obtaining the Opportunities Brought by Data: The UK Data Capability Strategy.” It proposed strengthening data analysis and processing technologies, increasing national infrastructure construction, promoting industrial research and development, sharing data results and ensuring data security, enhancing the UK’s international position in data mining and value extraction, and maintaining its economy at the forefront of the world. On August 31, 2015, the State Council of China issued the “Outline for the Promotion of Big Data Development,” which proposed comprehensively promoting the development and application of big data and accelerating the construction of data power [18]. The Ministry of Industry and Information Technology announced the “Growth Plan for Big Data Industry” on December 18, 2016, proposing strongly promoting the industry’s sustainable and healthy development during the “13th Five-Year Plan” term and executing the big data national strategy.

3. TCM Health Big Data Ecosystem

3.1. Big Data and Medical Information on Biological Data Mining. Mayer and Cukier proposed in the book “Big Data” developing new ideas for targeted applications by collecting and analyzing massive data. Progress and the development of science and technology will bring about new opportunities and challenges for biomedical applications. Genomics in the collaboration of big data technology, high-throughput chips, and deep sequencing technologies have achieved breakthrough growth. A large number of molecular markers and regulatory mechanisms in disease processes have been discovered, which have provided new ideas and new opportunities for treatment. Relevant advances bring technical support for all-around analysis and forecasting of medical development trends. Through big data mining and analysis, we deeply explore the nature of life, discover the laws of species development, and provide comprehensive services for human health [19]. Figure 1 shows the flow of big data and information in medicines.

3.2. Big Data and Traditional Chinese Medicine Application. The application and development of big data have promoted the development of biomedical science in an all-around way.
result, the development of TCM Health Big Data applications is realistic and can satisfy societal demands.

Firstly, health big data includes personal Chinese medicine data. The clinician can retrieve patient files at any time to understand the patient’s health status, past medical history, and medication history and use AI to compare data and differences between individuals and groups comprehensively to improve the accuracy of syndrome differentiation and the suitability of medication. Furthermore, with the development of the Internet of Things, cloud platform, cloud computing, and smart devices, big data can help the development of digital health and medical smart devices, realize the interconnection of clinical data, scientific research big data, and public health big data, and promote the birth and development of health medical big data applications. Finally, big data technology is effectively applied to its management. The standardized procedures and management rules are established in the aspects of health information collection, health data mining and analysis, and feedback and communication of health adjustment information. Some scholars have made a clear explanation of the construction of a TCM health management system and proposed building a “Chinese medicine brain,” with “9 major systems” and “81 modules” to establish a state-centered wisdom TCM Health Big Data system [23].

Big data is a booster to the Chinese medicine industry, providing new routes for growth, opening up new economic prospects, and allowing the Chinese medicine sector to better serve human health in all aspects.

4. Construction of TCM Big Data Ecosystem

Data is the basis for decision-making. By organizing, processing, analyzing, and visualizing data, it is possible to sum up, experience, discover patterns, and predict the future. Big data from daily life is huge, including financial transactions, scientific models, spatial telemetry, climate change, social media, e-mail, website browsing, document exchange, and medical images, most of which are unstructured data with the common characteristics of large volume, low value, and complex structure. Due to the development of the Internet, various unstructured data have grown at an alarming rate, making data processing a common problem in society. Therefore, it is particularly important to build a rational big data management framework.

Demchenko et al. [23] proposed looking at the entire big data system with the big data ecosystem. They believe that the entire big data ecosystem includes data attributes, data models and structures, data analysis, infrastructure, and security (also known as big data 5V: volume, speed, variety, value, and accuracy). Specifically, it includes big data infrastructure, big data analysis, big data structures and models, big data lifecycle management, and big data security.

In terms of Chinese medicine’s health big data ecosystem, it should be integrated into the ecological cycle. The TCM Health Big Data Ecosystem is a collection of human health states, including birth, old, sick, and dead, covering physiological and pathological characteristics, individual physique, and syndromes. It is a high level of awareness of life forms in time and space [24].

TCM Health Big Data has significant features of diversity and value. Through the holistic view of the unity of nature and human beings, TCM recognizes the world, diagnoses diseases, and pays attention to the health status and disease presentation of patients. Moreover, it may diagnose the status of one’s health by taking into account all aspects of society, environment, and psychology while using broad, extensive, and macroscopic cognition. To create a TCM health big data ecosystem, TCM combines the fundamental idea of “preventive treatment of disease” with big data technology and health management. We can achieve the goal of healthy lifestyles by conducting health status assessments and combining intelligent equipment with clinical data to provide appropriate health, treatment, health maintenance, and education programmes according to the health status of individuals. This involves status identification from the physical, psychological, social, and other multi-dimensional perspectives of individuals or the group.

The entire TCM big data ecosystem should include big data collection, big data integration and cleanup, big data analytics, big data storage, big data sharing, and publishing. The core part of the big data ecosystem is cloud computing.

Given this article’s ideas, this framework is used to map the TCM Health Big Data Ecosystem as shown in Figure 2.

4.1. Big Data Collection. Big data on TCM health comes from different levels such as macro, miso, and micro. In terms of information acquisition, the data is dynamic. Sources of individual health data include active acquisition and passive collection, including networks, smartphones, social networks, biometric data, sensor capture, smart wearable devices, and individual data. The cloud platform can effectively solve the problem of parameter acquisition. Internet of Things (IoT), cloud computing, wearable technology, and four-diagnosis instrument will be powerful tools for the full advantage of Chinese medicine. The intelligent wearable device and the portable four-diagnosis instrument can perform real-time dynamic continuous monitoring of individual life, working condition, exercise situation, mental state, psychological change, physical and chemical indicators, symptoms and signs, and postintervention reaction. Moreover, it can synchronize the cloud data and simultaneously capture information (astronomy, weather, luck, season, region, etc.) of the human society and natural environment.

One of the keys to data collection is the standardization of data. The clinical data can be standardized using the following equation:

$$J = \frac{(U - \beta)}{\delta},$$

where $\beta$ is the mean and $\delta$ is the standard deviation.

As far as clinical consultation is concerned, it is also a necessary measure to establish a sound system model for data collection. For example, completing the “asthma and
Chinese scholar Jifa et al. [26] pointed out that the development model from data, information, knowledge, and intelligence shows that the big data model created from traditional data must be optimized. Duplicate or unimportant data should be removed and the necessary data should be selected to convert unstructured data into structured data for retention.

For TCM health data processing, with the advancement of technology, the diversity of data sources is increasing (smartphones, smart wearable devices), and the amount of data is increasing at the geometric level. From the perspective of data optimization, data must be standardized and valid.

Data preprocessing must be performed before data analysis and data mining. The process of data preprocessing includes data normalization and appropriate quality control and generally processes for data cleansing, data integration, data conversion, and data reduction [27]. Data cleansing includes statistical techniques such as correcting and normalizing calculations based on predetermined values and deleting invalid and redundant data. Data integration will combine information from different sources to provide users with a comprehensive view. Data transformation includes smoothing, aggregation, generalization, and normalization to process data and new attribute construction. Normalization of data is usually accomplished using the following statistical technique:

$$K = \frac{(K - K_{minimum})}{(K - K_{maximum})}$$ (2)

Data reduction is the redundant processing of collected data, including data filtering, deletion, and compression.

There are many problems to be solved if big data technologies are applied to the field of TCM, such as dramatization of Chinese medicine content, as well as standardization of terminology, to better exploit the tacit knowledge. One of the main sources of data on clinical research in TCM is electronic medical records. The scope of application of electronic medical records is becoming more widespread, but it is difficult to merge different data systems. Unstructured data patterns cause obstacles in data extraction. Data duplication and missing in electronic medical records, test data gathering, and medical data cleansing are all contributing concerns. Because sorting makes future data analysis more complex and time-consuming, the acquisition of standardized clinical medical data will be beneficial for big data analysis. The terminology of traditional Chinese medicine, prescription, acupuncture, massage, health care, rehabilitation, medical history literature, and other disciplines will be regulated by the Ministry of Science and Technology’s special key project of science and technology basic work, which was launched in April 2012.

In the future, big data-based data mining should be combined with the cloud platform, statistical researchers, and medical workers, based on their quality of early warning, predictive, individualized, and shared, and discover hidden rules of TCM from massive amounts of knowledge.

4.3. Big Data Mining and Analysis. Big data mining and analysis refer to the process of extracting information and knowledge that is unknown but potentially valuable from massive, incomplete, noisy, fuzzy, or random application data for decision-making. As mentioned above, countries around the world attach great importance to big data analysis technology. Its mining and analysis are a specific type of data analysis and processing. Traditional data analysis methods can be used for references, such as cluster analysis, factor analysis, correlation analysis, regression analysis, statistical analysis, data mining algorithms, and structural equation modeling. It is essential to extract valid data with analytical methods to produce valuable results.

Data mining and analysis can predict future development. There are typical application cases in the research of TCM health big data. Through the introduction of large-scale and multiregional long-term systematic research, the theory of “five movements and six qi” and the pathogenesis of the disease are verified. Studying, verifying, and predicting

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**Figure 2: TCM Health Big Data Ecosystem.**

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4.2. Big Data Integration and Cleanup. According to a report by International Data Corporation (IDC), the total amount of data created and replicated in 2011 was 1.8 ZB. It is also expected that, by 2020, the world will have 35 ZB of data. Due to the emergence of massive data, the entire society will face enormous difficulties if data is not properly managed and intervened in.

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the prevalence of epidemics bring new ideas to the prevention and treatment of TCM epidemics.

Overall, big data mining and analytics for health care can help increase efficiency, reduce the clinical practice, shorten the development process, and be more efficient in public health. Figure 3 shows the integration of big data mining and analysis with machine learning and other algorithms.

4.4. Big Data Storage. Data storage refers to the storage and management of data and ensures its availability, reliability, and security.

A data storage system consists of two parts: infrastructure and a data storage mechanism. Traditional data is structured data, which is generally processed through a relational database and uses structured RDBMS for storage, management, and analysis. A relational database is highly transactional, requires high data integrity and security, and greatly reduces system availability and scalability.

With the emergence of big data, it is necessary to process a large amount of unstructured data. The relational database has a high concurrent response to massive data, performance is not ideal, and it is very easy to cause downtime. Therefore, a new kind of database system is needed to meet the needs of data processing.

As far as health care data is concerned, the early management system of patient disease can achieve the desired results by developing a data warehouse model due to the small amount of data and single content. However, with the advent of the era of big data, data from a large number of individual organisms have been captured, and the storage and retrieval of big data have reached an unprecedented new height. Although the establishment of a big data storage system can meet the growing demand for data processing by investing in hardware and software facilities, as the amount of data continues to grow, the development and maintenance of computer infrastructure for storing and processing data are expensive. For small- and medium-sized businesses, it is an unaffordable expenditure. Cloud computing’s evolution and maturity have made it the greatest answer for resolving this issue.

4.5. Cloud Platform

4.5.1. Cloud Platform and Services. Cloud platform operators typically offer four different modes of cloud services: public, private, hybrid, and community. The cost of using a public cloud is minimal, and it is extensively employed by small- and medium-sized businesses. Private clouds are mostly used by large businesses with stringent data security and dependability needs. Hybrid clouds are typically given by system integrators that utilize their technology to combine the services of many cloud platform service providers to deliver more customized services to fulfill a variety of client customization requirements. The use of community clouds for specific scenarios is mostly for the vertical market and is appropriate for firms with a set of similar requirements [28].

Different cloud services provide powerful cloud computing services in four different types and levels: Data as a Service (DaaS), Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS).

Cloud platforms and cloud computing can effectively reduce the cost of ownership (TCO). It has a significant positive impact on the organization’s IT use costs, brings new business possibilities to the organization, and brings macroeconomic performance to the enterprise.

Data mining and big data analytics are important fields of cloud computing applications. As a new and important big data processing tool, cloud computing has been successfully applied in many fields. Cloud computing is increasingly used in various frontier scientific researches, technology development, and engineering design. Cloud computing has become important for increasingly technological innovation.

4.5.2. Cloud Computing and TCM Big Data. Cloud computing is an important technology for big data storage and analysis. It is widely used in human genomics, proteomics, medicine design, and molecular dynamics simulation. It also plays an important role in the field of health management, including a health-monitoring system with a large amount of data processing, integrating user social media data, and monitoring the mobility of users through wearable hardware. The integration of smart devices allows individuals to continuously collect physiological indicators, signs and symptoms, exercise data, living conditions, and even diets at any time and space. Through cloud computing technology, the data is monitored for a long time, and tracking analysis is carried out. When the data changes, timely feedback is provided to maximize the health management effect.

The aggregation of data provides a possibility for data mining analysis of TCM health management. With the superior computing power of the cloud platform, clustering analysis, correlation analysis, sequence mining, graph mining, and text mining data algorithms are used to find the
implicit connection between data, discover unknown rules, and finally obtain knowledge, which can establish a TCM thinking algorithm model.

Data mining and data analysis are two applications of cloud computing in the field of TCM. Currently, it is mostly concerned with the study of prescription compatibility guidelines and TCM symptoms. In the future, it is more likely to conduct pioneering application research in the fields of genomics of traditional Chinese medicine, virtual drug screening of new Chinese medicines, and simulation of Chinese medicine data by referring to computational biology research methods. The application of cloud computing in the field of TCM will have a profound impact on the innovation and development of TCM research methods.

4.6. Big Data Communication and Visualization. With the advancement of the Internet, sharing public data has become an important part of the national big data strategy. From privacy to openness, more government budgets, resources, and usage rules are needed to ensure that data is used safely. In particular, health big data based on personal data is necessary to improve relevant laws and regulations and designate effective regulatory systems. Big data in health care is an important basic strategic resource for the country. The development of big data in health care applications will bring about profound changes in the management service model, which will help improve the efficiency and quality of health care services [29].

In the sharing application of the health data, the health management center or the community doctor can view the change of the healthy state parameter of the management object through the Internet or the mobile terminal application and propose health care or medication discussion for the health state of the management object in real time. When the vital signs of related individuals are abnormal, the cloud platform can preset the automatic alarm function such as notifying the management object to go to the hospital for medical treatment through the network and informing the family and the custodial doctor. Patients can also learn about their physical condition through the Internet and learn medical knowledge.

The Chinese government actively plans for the opening and application of TCM Health Big Data, for instance, the establishment of a national big data platform for the treatment of kidney disease in Chinese medicine, and proposes using data sharing as the basis, reciprocal progress as the guideline, and return to society as the goal. Through the collection, management, sharing, and utilization of big data, the patient’s onset diagnosis and treatment data and cost information are shared [30].

5. Conclusion

Presently, AI has infiltrated all fields of life. Particularly, the growth of big data and AI has brought extraordinary opportunities and challenges in all fields including health care and medicine. This study proposed the processing flow and overall framework of TCM health using big data and presented a feasible solution for the management and application of TCM big data. Next, a TCM Big Data Ecosystem is proposed. The ultimate goal of the establishment of the TCM Health Big Data Ecosystem is to provide personal scientific and effective health management, protect the body from diseases, improve the physical and mental health, and improve the ability to adapt to the natural and social environment. Furthermore, with big data technology, the health status is measured and collected from a multidimensional perspective, and the health information is stored and comprehensively analyzed. At the same time, the “preventive treatment of disease” of TCM is used to guide the prevention and treatment of diseases to improve the quality of life and satisfaction. The TCM Health Big Data Ecosystem also faces challenges. The objectification and standardization of TCM data need to form a consensus and be standardized early. The legislation on data sharing and privacy protection is also urgent. Future work is required to develop smart devices, provide high data accuracy, and solve the issues of data reliability.

Data Availability

The data used to support the findings of this study are included within the article.

Disclosure

Haitao Cheng and JunWei Li are the co-first authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors’ Contributions

Haitao Cheng and JunWei Li contributed to this work.

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