Modern Management based on Big Data III
A.J. Tallón-Ballesteros (Ed.)

doi:10.3233/FAIA220112

Development Status and Trend Analysis of Internet of Medical Things Industry in China

Jian JIAO [a, 1]
[a] *Institutes of Science and Development, Chinese Academy of Sciences, P. R. China*

Abstract. This article analyzes the development status, development trend and prospects of China's Internet of Medical Things (IoMT) industry from a macro perspective. Our survey mainly includes: analyzing the necessity and urgency of China's medical system reform from the various dilemmas faced by China's medical system, and analyzing the development of the IoMT industry based on the current basic conditions of development of the Internet of Things (IoT), information technology and background of COVID-19 epidemic. Opportunities and the evolution of China's IoMT policy were also analyzed. Moreover, from the five aspects of medical industry informatization, Internet hospitals, smart wearable devices, medical AI industry and medical industry digitization, the development status and trends of China's IoMT industry are analyzed. Finally, it looks forward to the development prospects and directions of IoMT industry for health care in China.

Keywords. IoMT, China's medical system, development status, health care

1. Introduction

Internet of Medical Things (IoMT) generally refers to all medical treatment and market behaviors carried out by the Internet platform and the concept of Internet of Things (IoT) [1-2]. The subjects of behavior include Internet companies, hospitals, insurance companies, doctors, patients, and other users with medical and health management needs. The purpose of "nodes" is to accurately match patient groups and obtain accurate and comprehensive health information through the combination of the Internet, enhance health services and information transparency, enhance the interconnection of various elements of medicine and health, and achieve the effect of precision medical treatment [3]. In brief, this article analyzes the difficulties faced by China's medical system, analyzes the development opportunities, policy evolution, development status and development trends of China's IoMT industry from a macro level, and looks forward to the future development prospects of IoMT in China.

[1] Corresponding Author, Institutes of Science and Development, Chinese Academy of Sciences, P. R. China; E-mail: jiaojian@casisd.cn.

2. Difficulties and problems of China's medical system

2.1. Medical resources are unevenly distributed in the east and west of China with uneven distribution of good and bad

According to public data from the 2019 China Health Statistics Yearbook, the total number of Third-class hospitals in eastern medical institutions and the number of tertiary hospitals is significantly more than those in the central and western regions. Moreover, the total number of health technicians and practicing doctors in the eastern region have absolute advantages over the central and western regions. In general, the total medical resources and high-quality medical resources in the east have significant advantages. In terms of regions, the difference between urban and rural areas cannot be underestimated. High-quality medical resources are basically concentrated in cities. According to data from the National Bureau of Statistics, rural basic medical resources are in vain, and it is difficult to meet the health and medical needs of the vast rural population.

2.2. Excessive medical treatment exists, and the balance of screening and measurement mechanisms has not yet been reached

According to estimates by the World Health Organization (WHO), the global health sector spends US$7.1 trillion each year, of which 20%-40% is wasted in technical means or strategies that are not optimal or unnecessary in terms of cost-effectiveness, that is, the ratio of input to output is not the best way. In China, over-medicine exists for a long time due to problems such as "medicine to support doctors", relatively lagging medical concepts, and distrust between doctors and patients. For example, in 2017, the journal "Lancet" pointed out that China has problems with the abuse of antibiotics and the high rate of cesarean section [4]. Therefore, how to make better use of medical resources and avoid excessive medical treatment will have more practical significance for China.

3. Opportunities for the development of IoMT industry in China

3.1. Combine IoT to build a patient-centered hierarchical diagnosis and treatment platform

As the highlight of China's medical reform, hierarchical diagnosis and treatment means that medical institutions at all levels in China classify various diseases according to the severity of the disease and the difficulty of treatment, and undertake the treatment of diseases of different levels. Under the hierarchical treatment system, common diseases are mostly diagnosed and treated in first-level medical institutions, chronic diseases are often diagnosed and treated in second-level medical institutions, and difficult or critical diseases are treated in third-level large-scale comprehensive medical institutions.

Based on this, the realization of hierarchical diagnosis and treatment must face up to and solve two major dilemmas: on the one hand, the flexible use of IoT to allocate medical resources, so that doctors can flow between the community and the hospital, and further realize the reasonable distribution of doctor resources; on the other hand,

reasonably use the Internet of Things for patient diversion and treatment, implement patient-centeredness, and allow medical resources to be used rationally [5].

3.2. The COVID-19 epidemic boosts the development of IoMT industry

During the COVID-19 pandemic, people were forced to stay at home, and the advantages of digital medical care have gradually emerged, such as more convenient online services, more doctor resources in departments, and at the same time avoiding the risk of nosocomial infection [6-8]. During the epidemic period of home isolation and tight medical resources, patients' demand for online medical services is rapidly increasing due to the consideration of reducing the probability of nosocomial infection.

3.3. New technologies accelerate the digital transformation of healthcare and medicine

The acceleration of China's new infrastructure and the rapid development of 5G, cloud computing, big data, IoT, artificial intelligence, blockchain, virtual reality and other technologies have injected a "cardiotonic agent" into the development of the IoMT industry. In the post- COVID-19 epidemic era, digital technology has come to the forefront and has become an emerging force driving the digital transformation and upgrading of China's medical and pharmaceutical industries [9].

4. The policy evolution of IoMT in China

Overall, China's IoMT policies have mainly experienced three stages: the promotion period, the austerity period and the standardization period, and they are gradually embodying the characteristics of standardization, top-levelization, and clarity. Especially since 2018, policies in the national IoMT field have been intensively introduced, and various provinces and cities are also accelerating the construction of provincial-level internet medical service supervision platforms (Table 1).

Table 1. Policies related to IoMT of China in recent years.

Date	Name of Policy
September 2005	Interim Provisions on the Approval of Internet Drug Transaction Services
October 2013	Notice on Strengthening the Administration of Internet Drug Sales
August 2014	Opinions on the Promotion of Telemedicine Services in Medical Institutions
July 2015	Guiding Opinions on Actively Promoting the "Internet +" Action
January 2017	"Thirteenth Five-Year" Hygiene and Health Plan
July 2018	Trial Implementation of Internet Hospital Management Measures
September 2018	National Health and Medical Big Data Standards, Safety and Service Management Trial Measures
February 2020	Notice on Internet Diagnosis and Treatment Consultation Services in the Prevention and Control of COVID-19 epidemic
March 2020	Guiding Opinions on Promoting the Development of "Internet+" Medical Insurance Services During the Period of Prevention and Control of COVID-19 epidemic
April 2020	Regarding the Implementation Plan for Advancing the "Data Empowered AI" Action and Cultivating New Economic Development

The policy promotion period is from 2014 to 2015 year. In August 2014, the National Health Commission of the People's Republic of China issued the "Opinions on Promoting Telemedicine Services in Medical Institutions", encouraging localities to establish telemedicine service platforms. In July 2016, National Medical Products Administration notified Hebei Province, Shanghai, and Guangdong Province to end the pilot work of drug online retail on third-party Internet platforms. In April 2017, the state suspended the use of names such as "Internet Hospital", "Cloud Hospital", and "Network Hospital". From 2018 to 2019, IoMT has entered a period of policy regulation. In August 2019, National Healthcare Security Administration issued the "Guiding Opinions on Improving Internet + Medical Service Prices and Medical Insurance Payment Policies", which included Internet + medical services into the scope of medical insurance payment for the first time.

5. Development status and trend of IoMT industry in China

IoMT is closely related to the development of the Internet itself. In general, China's IoMT has gone through an era dominated by PC mutual and mobile Internet, and is currently in the transitional stage of transitioning to Internet hospitals. Eventually, comprehensive IoMT care will be realized, including services such as online consultation, diagnosis, remote treatment, prescription, and delivery of medicines to home. At present, China's IoMT industry has integrated many participants such as mobile medical service providers, medical equipment manufacturers, IT giants, venture capital, mobile operators, application developers, data companies, and insurance companies, forming an IoT-based healthcare industry. And, the industrial structure dominated by insurance and online medical care [10].

In recent years, with favorable policies, technological progress, and increased residents' health awareness, China's IoMT market has developed rapidly, with a compound annual growth rate of more than 30%. According to our survey and research, the market size of China's IoMT has reached 41 billion RMB in 2020 (Figure 1).

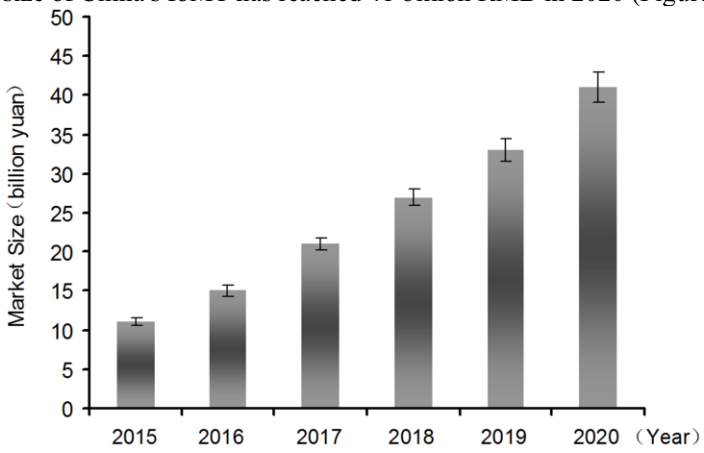

Figure 1. The market size of China's IoMT from 2015 to 2020

5.1. Informatization of medical industry

Hospitals are the main target of medical informatization. The IT system built around hospital informatization supports medical care, medical insurance, and medicine respectively, and is the main link of medical informatization. Among them, medical IT is the core, mainly including hospital management system, image archiving and management system, hierarchical diagnosis, and treatment platform, etc. Most of the major enterprises that carry hospital informatization are concentrated in established medical software and hardware companies, which have inherent advantages in hospital resources. As the technical level and level requirements of medical information systems become higher and higher, small and medium-sized manufacturers with average technical strength and low product reliability will be gradually eliminated. At present, the competitive landscape of the domestic medical informationization market will gradually move closer to mature markets, and industry concentration will gradually increase [11].

5.2. Internet hospital

Internet hospitals are the online model of physical hospitals. According to the "Internet Hospital Management Measures (Trial)" issued by National Health Commission in September 2018, Internet hospitals must have physical medical institutions as offline support, and the setting of departments and diagnosis and treatment subjects that Internet hospitals can carry out shall not exceed the physical medical care they rely on. Our survey found that among the more than 100 Internet hospitals nationwide in 2019, hospital-led Internet hospitals accounted for 41%, and enterprise-led Internet hospitals accounted for 59%. During the COVID-19 epidemic, the rapidly growing demand for home consultations, and the promulgation of multiple policies by relevant authorities, have made Internet hospitals get multiple benefits [12].

5.3. Smart wearable device

The gap between China's medical supply and demand has brought new opportunities for wearable medical devices. Wearable medical equipment has a bright future. The main reasons are as follows: on the one hand, China's aging population has caused a rapid increase in medical demand; on the other hand, China's medical resources are seriously short of supply, especially in remote areas. In the future, patients with chronic diseases such as coronary heart disease, hypertension, and diabetes will not only receive drug treatment, but also receive overall disease management programs including remote monitoring, remote treatment program adjustment, lifestyle management, and wearable drug delivery. At present, China's medical wearable devices are still in the initial stage of development. It is foreseeable that smart wearable devices rely heavily on big data infrastructure and network operations. Quickly accumulating users and obtaining user health data is the primary issue, and data issues will become industry barriers [13].

5.4. Medical AI industry

In recent years, China's smart medical market demand has continued to grow, and the market scale has expanded rapidly, and it has become the world's third largest smart

medical market after the United States and Japan. Our survey found that as of March 2021, China has 2,245 companies involved in the medical AI business, including 19 listed companies. Among them, judging from the research direction and layout of enterprises in Jiangsu, Zhejiang and Shanghai (about 143), medical imaging and auxiliary diagnosis and treatment are the two most popular directions. There are a total of 45 AI companies assembled, accounting for more than 30% of the entire AI market share. But at the same time, there are still many companies heading towards chatbots, disease risk prediction, drug discovery, and health management. Overall, the segmented track of Chinese medical AI companies presents a decentralized competition.

5.5. Digitalization of medical industry

Digitization is the foundation of IoT, including the procurement of medical laboratory equipment, reagents and consumables, technical outsourcing service customization, to intermediate links such as consultation, appointment, diagnosis, treatment, medication and rehabilitation, to the delivery of final products, services, and medical insurance [14]. At present, the degree of digitalization of the supply-side and demand-side enterprise management of medical elements is relatively low, which is a key transformation link of the medical industry chain [15-16]. The industrial Internet of Things platform will be an important driver of digitalization, and gradually realize the digitalization of procurement, digitalization of production, digitalization of management, digitalization of marketing, and transactions.

6. Conclusion and Prospects

With the integration and application of IoT technology for health care, 5G communication networks, AI technology, big data, cloud computing and other intelligent technologies, and a new generation of information technology in Internet medical care, the IoMT industry will form functions such as "sensing-connection-convergence-integration-analysis-decision-making". The linked system support system promotes the gradual upgrade and maturity of Internet medical application scenarios that are characterized by intelligence, networking, remoteness, and mobility, and accelerates the process of large-scale applications [14].

The IoMT industry in China will enter a period of rapid growth of intelligent, efficient, and large-scale development. In the future, IoMT will become a "new kinetic energy" to promote the rapid development of China's digital economy. At the terminal level, intelligent medical equipment and terminal equipment will accelerate the popularization and application, which is concentrated in wireless intelligent diagnosis and treatment equipment and wearable intelligent monitoring equipment. At the network layer, 5G application scenarios are adapted to the needs of wireless medical and health scenarios, and enhanced mobile broadband can provide emergency vehicles with continuous wide-area coverage and achieve "getting on the car and entering the hospital". At the platform level, technologies such as cloud computing, big data, artificial intelligence, and blockchain will promote the transformation and upgrading of medical information and telemedicine platforms. At the application level, 5G medical applications have unlimited potential, and intelligence and personalization are the two major development directions [17-18].

In general, China's IoMT industry is still in the exploratory stage. However, judging from the rapid development in recent years, whether it is driven by market demand or the inevitable result of technological progress and integration, IoMT industry still needs to be human-centric and data-driven. While improving the effectiveness of medical treatment, only by identifying medical pain points can medical services better meet people's health needs.

References

[1] Alqaralleh BAY, Vaiyapuri T, Parvathy VS, et al. Blockchain-assisted secure image transmission and diagnosis model on Internet of Medical Things Environment. Pers. Ubiquit. Comput. 2021: https://doi.org/10.1007/s00779-021-01543-2.
[2] Bajaj A, Bhatnagar M, Chauhan A. Recent trends in internet of medical things: a review. Advances in Machine Learning and Computational Intelligence. Algorithms for Intelligent Systems. Springer, Singapore. 2012: https://doi.org/10.1007/978-981-15-5243-4_61.
[3] Ding Y, Wu GZ, Chen DJ, et al. DeepEDN: A deep learning-based image encryption and decryption network for Internet of Medical Things. IEEE Internet Things. 2021; 8(3): 1504-1518.
[4] Yang XJ, Sun SS. Comparison of maternal and fetal complications in elective and emergency cesarean section: a systematic review and meta-analysis. Arch. Gynecol. Obstet. 2017; 296: 503–512.
[5] Deebak BD, Al-Turjman F. Smart mutual authentication protocol for cloud based medical healthcare systems using Internet of Medical Things. IEEE J. Sel. Areas Commun. 2021; 39(2): 346–360.
[6] Ahmad S, Ali N, Kausar M, et al. Road toward rapid molecular point of care test to detect novel SARS-coronavirus 2019 (COVID-19): review from updated literature. Allergol. Immunopath. 2020; DOI: 10.1016/j.aller.2020.06.001.
[7] Fabiani L, Saroglia M, Galata G, et al. Magnetic beads combined with carbon black-based screen-printed electrodes for COVID-19: A reliable and miniaturized electrochemical immunosensor for SARS-CoV-2 detection in saliva-ScienceDirect. Biosens. Bioelectron. 2020; DOI: 10.1016/j.bios.2020.112686.
[8] Lin B, Wu SJ. COVID-19 (Coronavirus Disease 2019): Opportunities and challenges for digital health and the Internet of Medical Things in China. Omics: J. Integra. Biol. 2020; DOI:10.1089/omi.2020.0047
[9] Al-Turjman F, Nawaz MH, Ulusar UD. Intelligence in the Internet of Medical Things era: a systematic review of current and future trends. Comput. Commun. 2019; DOI: 10.1016/j.comcom.2019.12.030.
[10] Joyia GJ, Liaqat RM, Farooq A, et al. Internet of medical things (IOMT): applications, benefits and future challenges in healthcare domain. J. Commun. 2017; 12: 240-247.
[11] Arthur G, Youakim B, Bertrand M, et al. Internet of Medical Things: A review of recent contributions dealing with cyber-physical systems in medicine. IEEE Internet Things. 2018; DOI: 10.1109/JIOT.2018.2849014.
[12] Manogaran G, Chilamkurti N, Hsu CH, et al. Emerging trends, issues, and challenges in Internet of Medical Things and wireless networks. Pers. Ubiqui. Compu. 2018; DOI: 10.1007/s00779-018-1178-6.
[13] Basatneh R, Najafi B, Armstrong DG. Health sensors, smart home devices, and the Internet of Medical Things: an opportunity for dramatic improvement in care for the lower extremity complications of diabetes. J. Diabetes Sci. Technol. 2018; DOI: 10.1177/1932296818768618.
[14] Oniani S, Marques G, Barnovi S, et al. Artificial intelligence for Internet of Things and enhanced medical systems. 2021; ISBN: 978-981-15-5494-0.
[15] Gupta D, Gupta U. On robust asymmetric Lagrangian ν-twin support vector regression using pinball loss function. Appl. Soft Comput. 2021; DOI: 10.1016/j.asoc.2021.107099.
[16] Gupta U, Gupta D. On Regularization Based Twin Support Vector Regression with Huber Loss. Neural Process. Lett. 2021; DOI: 10.1007/s11063-020-10380-y.
[17] Balasubramanian V, Jolfaei A. A scalable framework for healthcare monitoring application using the Internet of Medical Things. Softw. Pract. Exper. 2020; DOI: 10.1002/spe.2849.
[18] Gao L, Liu L, Zhang J, et al. Building of smart home medical system based on Internet of Things. Internet Things Cloud Comput. 2016; DOI: 10.11648/j.iotcc.20160403.14.