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Research and Exploration of a "Medical and Nursing Care Smart Linking" Elderly Care Model

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Abstract: China faces difficult challenges due to its aging population. The country's endowment system is still in its infancy, and pensions have become a major problem requiring prompt resolution. Based on China's national policies, this paper proposes a "medical and nursing care smart linking" elderly care system centered on a large hospital for diagnosis and treatment. This system uses the Internet to connect institutional, community, and family pension models and employs new cloud-based artificial intelligence for diagnosis and rehabilitation. Related work has shown that the use of the Internet, advanced artificial intelligence, and other effective comprehensive treatment technologies to solve the current problems facing China's pension industry has important research value. These are very promising efforts that are in line with national development strategies and relevant policies.

Keywords: "medical and nursing care smart linking"; smart elderly care; Internet; artificial intelligence; auxiliary diagnosis and treatment

1 Introduction

According to the *2014 China Statistical Yearbook*, China has been an aging society since 1999. By 2014, the country's population of people above 65 years had grown to 137.55 million, accounting for 10.1% of the total population. It is estimated that, by 2030, the percentage of China's population aged over 60 will reach 25% [1]. In addition, the number of disabled and semi-disabled elderly people is growing. China is undergoing a critical period of rapid economic development and restructuring. Considering this background, the issue of elderly care is a key task requiring urgent resolution by the Chinese government. However, China's pension service system currently lags behind the demand for elderly services, and the supply of resources for the older population is insufficient and unbalanced. Therefore, China's pension system must be further explored and improved. In view of the existing problems of China's current pension model and elderly care system, this paper proposes a "medical and nursing care smart linking" pension system, which makes full use of technologies such as the Internet of Things (IoT), the Internet, big data, machine learning, and modern biomedicine. These high-quality medical care technologies can be employed in every aspect of elderly care to improve the efficiency and quality of the operation of the pension system.

2 Overview of existing elderly care models

2.1 Review of foreign elderly care models

2.1.1 Home care service

European countries have developed and implemented four main types of home care services. The first is the fully equipped "retirement home," which provides complete facilities and thoughtful service. The second is the "care center," which provides daytime support, allowing elderly people to receive care during the day and then return home to rest at night. Such cen-

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ters are fully equipped and offer high-quality services. In the third system, "mutual support" is organized for the elderly such that they can spend time together and help each other. The fourth system is the "home care worker" system, which is the most prevalent home care service.

2.1.2 Elderly community service

Elderly communities are generally divided into four categories: self-care, life-assisted, special care, and continuing care after retirement. Such communities work closely with hospitals and professional care organizations.

2.1.3 Integrated care service model

"Integrated care" is a policy concept promoted in the field of social care in the past decade. It is a method of resource integration for the "dual track system" of health care and social care in public services for the elderly. The aim of integrated care is to eliminate the segmentation of traditional health departments and social service departments and improve resource utilization and service quality. The UK's "integrated care" concept refers to the integration of basic care, community care, and social care through the establishment of joint institutions centered on caretakers to provide continuous high-quality care services.

2.2 Analysis of China's pension model

China implements a "90-7-3" pension model in which 90% of elderly citizens receive care through family pensions, 7% through community care, and 3% from institutions. With the government's emphasis on pension services and chronic disease management and the current rapid development of the Internet industry, local governments are actively exploring innovative retirement models and improving elderly care services. *The 12th Five-Year Plan for the Development of China's Ageing Cause* and *Construction Plan of Social Service System for the Elderly (2011–2015)* issued by the State Council express that one of China's development goals is to make the home-based, community-dependent, institution-assisted, and medical-care-combined pension service system more robust.

2.3 Challenges faced by China's pension model

2.3.1 Lack of chronic disease care technology in pension institutions and communities

China's current elderly care system lacks standardized institutions that form a professional nursing system for health rehabilitation as well as effective medical technology and equipment.

2.3.2 Huge family pension pressure

The current family model in China is based on a "4-2-1" family model in which a young couple supports four elderly people and raises one child. Managing the daily care of four elderly people, particularly regarding the diagnosis and treatment of geriatric diseases, is not an easy task for two young people.

2.3.3 The lack of nursing staff and low level of medical professionalism

At present, there are fewer than 1 million nursing staff working in domestic pension institutions, and fewer than 20,000 of these hold professional nursing certificates. Domestic pension institutions lack mechanisms for attracting professional medical staff. Therefore, most of the employees in such institutions are laid-off workers or retirees who have a low level of education and little professional medical knowledge. As a result, the overall service level of such pension institutions is not high.

2.3.4 Pension agencies are in short supply

At present, there are about 38 060 elderly care institutions in China with a total of 2 662 million beds; the current number of beds for the elderly is only 1.59% of the national elderly population [2].

2.4 Current "medical-nursing-combined" model

According to the *Third National Survey of Death Causes*, chronic disease is the main cause of death in the Chinese population, and most elderly people have chronic diseases. According to *The Plan for Development of National Ageing Cause and Construction of Pension System During the "13th Five-Year Plan"* issued by the State Council, one of China's development goals is to make the medical-nursing-combined pension service system more robust. It is clear that the "medical-nursing-combined" model is the leading trend of future pension development. The four main forms of this model are described below.

(1) Medical institutions cooperate with elderly care institutions to establish a green channel by signing a cooperation agreement. The goal of this form of elderly care is to build nursing homes near community service centers. Community health service centers can provide services like regular family visits for medical care, emergency treatment, and timely transfer treatment. This format is simple, flexible, and diverse, which can effectively alleviate the phenomenon that "one bed is hard to find" in pension institutions. At the same time, this format may suffer from problems such as loose medical resource management, insufficient institutional constraints, and low-efficiency and unsatisfactory medical service.

(2) Elderly care institutions provide medical agencies, rehabilitation centers, and nursing facilities. Medical care can be provided by setting up clinics, outpatient departments, and even independent hospitals in elderly care institutions. For example, the health clinic at Shandong Jiao Zhou Nursing Home provides medical examinations and physical health monitoring services. The advantage of this format is that the efficiency and quality of elderly care are high, but there is a lack of high-level medical

resources. Availability in such elderly care institutions is often difficult to find.

(3) Health care services extend to the family community, and community doctors provide services such as family visits, community care, and family beds. This mainly relies on the community health service network to provide on-site services to the elderly through the implementation of the family doctor model. This format is characterized by a large service team, including doctors, nurses, nursing staff, and psychologists. The main service targets of this format are elderly people who require medical rehabilitation services at home, such as those with limited mobility or without children. This form depends mainly on people who provide on-site services, and its operation pressure is huge when community medical staff are scarce.

(4) Medical institutions provide elderly care services. Existing hospitals and community medical service centers can begin providing elderly services as long as they meet the conditions. Combined with the current reform of public hospitals, typical medical institutions can be transformed into rehabilitation or nursing hospitals to provide comprehensive and continuous elderly care services for the surrounding communities. This format has normative industry standards in medical service and personnel management, but resources are limited; the incentive mechanism for hospitals is not sufficient and doctors usually lack motivation.

Among the above four forms of the "medical-nursing-combined" model, the shortage of high-quality medical resources is a key issue requiring urgent resolution. The rapid development of the Internet and artificial intelligence (AI) technology provides a new way to support the operation of the "medical-nursing-combined" system. Technologies that can remotely sample health status and cloud services using AI to make diagnoses provide an important auxiliary means for interactions between doctors and patients. This paper proposes a new elderly care system supported by advanced technologies such as the Internet, the IoT, and AI and is led by large hospitals to realize a "medical and nursing care smart linking" elderly care system.

3 "Medical and nursing care smart linking" elderly care system

The "medical and nursing care smart linking" elderly care system integrates the Internet and AI with modern rehabilitation technology for geriatric diseases to form a support platform and complements the advantages of hospitals, elderly care institutions, community clinics, and households to build a distributed management model. Unlike the general "medical-nursing-combined" model, this model is mainly led by large-scale hospitals for medical treatment. It is characterized by the construction of a "rehabilitation medical support chain" that relies on hospitals linking to centralized elderly care institutions and radiating to families in the community. Aimed at sustainable development of elderly care institutions and community- and home-based service chains, the organic link based on AI and the Internet among hospitals, elderly care institutions, communities, and families provides a new solution for China's elderly care problem. A diagram of this system is shown in Fig. 1.

Under the guidance of related national pension policies such as grading diagnosis and medical association construction, the "medical and nursing care smart linking" system provides professional rehabilitation guidance from the related departments of large hospitals, which have rich medical resources, and uses the Internet as a means of communication to realize medical care for community hospitals and elderly care institutions. At the same time, technologies such as medical image AI-assisted diagnosis, virtual reality (VR)-assisted rehabilitation, and gait recognition-assisted rehabilitation can obtain intelligent auxiliary diagnosis and treatment that can then be referenced by medical staff. This system can alleviate the pressure on relevant personnel, improve the user experience of the elderly, and achieve an all-around, multi-level, high-quality "medical and nursing care smart linking" pension system. So far, primary research has been conducted among functional modules in relevant hospitals, elderly care institutions, and local families in Zhejiang Province, and the system has been well received by experts.

3.1 Specification and application of elderly care big data

With the development of Internet technologies, several pension information platforms have emerged throughout China. However, most of these are at an early stage of development and only provide a single service, making it difficult to support the diagnosis and treatment of geriatric diseases, which require different data specifications. There is a lack of professional guidance or unified standards, and each platform works independently, so data are not shared.

In response to these problems, it is crucial to share trusted data and build a secure operation mechanism among hospitals, elderly care institutions, and community families. Fig. 2 shows the architecture of the information data platform of the "medical and nursing care smart linking" pension system proposed in this paper.

The platform connects home, community, and institutional care systems through the Internet and AI care services and combines genetic data to share a pension data cloud platform shared by large hospitals, nursing homes, and related government institutions. Community civil affairs-related departments can provide licensed data for the system database, and, as each large hospital has its own database, its services can be connected to community hospitals. Through the IoT technology, the data obtained by sensors or wearable devices are first sent to the community hospital database center by each family. If abnormal data indicate a dangerous situation for the elderly user, an alarm is issued to facilitate the timely arrival of emergency services personnel. In

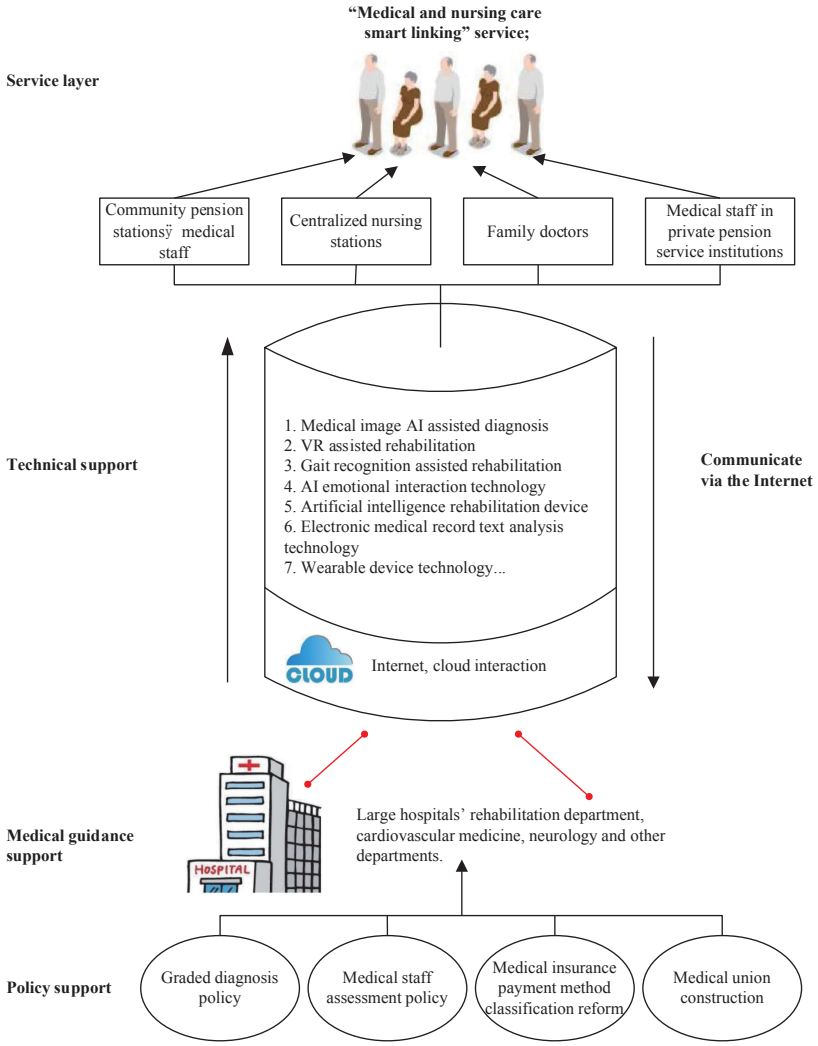

Fig. 1. “Medical and nursing care smart linking” system architecture diagram.

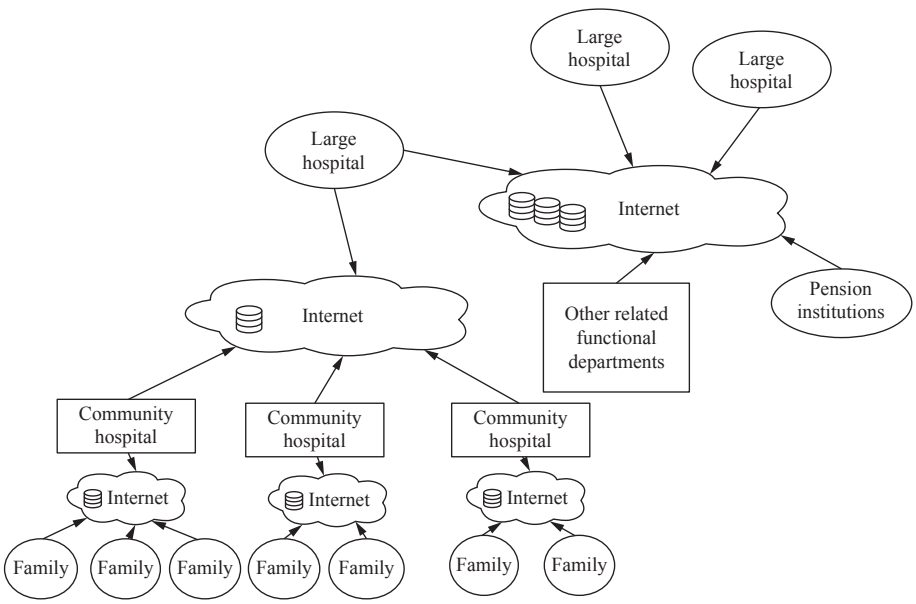

Fig. 2. The architecture of the information data platform.

addition, the elderly user's body-monitoring data can be sent to a large hospital's rehabilitation department for professional remote rehabilitation guidance. At the same time, nursing homes can sign contracts with hospitals, join the system platform to obtain professional technical support, and improve the quality of their services. The addition of larger hospitals can expand the scale of the entire system.

3.2 Application of diagnosis and treatment technologies in smart elderly care

The "medical and nursing care smart linking" rehabilitation system proposed in this paper uses the Internet to build a trusted and secure data sharing platform. At the same time, it uses Internet technologies to develop smart diagnosis and treatment technology for geriatric diseases. IoT technology, AI, VR, and other intelligent software technologies can be integrated with medical systems and combined with genetic technologies, penetrating all aspects of elderly rehabilitation and striving to maximize the efficiency and quality of elderly rehabilitation while reducing the costs of manpower and time to alleviate the challenges of the current pension model. The key technologies of Internet smart diagnosis and treatment for geriatric diseases to be studied are discussed below.

3.2.1 Smart sensing and VR technology in the diagnosis and treatment of geriatric diseases

Existing methods of elderly rehabilitation mainly provide function training for elderly patients with dyskinesia, including passive exercise of the limbs, active and resistance exercises, and "homework therapy." These rehabilitation methods generally require the presence of professional nursing staff, and the training process is rather boring. At this time, the emergence of VR technology has been well applied in the process of rehabilitation training. Reasonable virtual environment settings and various forms of information feedback can make the tedious and mechanical recovery training vivid and interesting. The application of VR technology in rehabilitation initially focused on the rehabilitation of shoulder and elbow joints. With the development of data gloves and other hand-sensing devices, the VR-based hand function rehabilitation training system has made great progress.

Rutgers University has developed a rehabilitation training system called Rutgers Arm II [3], which consists of infrared vision tracking, gravity, and personal computer-based VR game modules. The Rutgers Arm II trains patients' hand–eye coordination ability, arm movement speed, palm grip strength and control force and arm endurance as well as the range of motion of the shoulder joint. Connelly et al. of the Chicago Rehabilitation Center designed a pneumatic data glove (PneuGlove) combined with VR [4] and a helmet display device that presents a stereoscopic 3D effect. The patient controls a virtual hand to grasp and release objects that randomly appear in the virtual environment using a glove equipped with sensors, thereby training the patient's wrist joint and the metacarpophalangeal joint flexion and extension movement. The Fugl-Meyer evaluation of two groups of stroke patients using this system shows that VR technology can significantly improve patient rehabilitation.

With the rapid development of 4G and 5G mobile technologies in China, research on smart sensors and VR diagnosis and treatment software and hardware technology based on Internet cloud services is not only an important innovation in science but can also make significant contributions to the development of China's elderly care industry.

3.2.2 Robot-assisted rehabilitation technology for geriatrics

Limb motor dysfunction caused by moderate strokes, such as patients with Parkinson's disease (PD) with resting tremors and bradykinesia and reduction, occurs frequently in the elderly population. In addition to the traditional physical training performed by physical therapists, intelligent rehabilitation through robot-assisted diagnosis and treatment technology has important research significance and application value. Existing rehabilitation methods require professional nursing staff to adjust equipment parameters, though the use of Internet technology and machine learning algorithms can realize remote monitoring of rehabilitation, which can reduce labor costs and improve rehabilitation efficiency.

An additional new rehabilitation technology is a five-degrees-of-freedom wearable upper limb rehabilitation robot that can facilitate single and multiple joint exercises [5]. The robot uses surface electromyography signals (sEMGs) of the limb movements of hemiplegia patients to drive the robotic arm and assist in the rehabilitation of patient's limbs. A neural network was used to establish the model to obtain the relationship between the sEMG and upper limb rehabilitation. Another related technology is an anti-shock bracelet for PD patients equipped with a pulse electrode that generates electrical stimulation pulses to the phrenic nerve of the patient's hand to counteract hand tremors [6]. While this technology has obvious benefits, it requires frequent visits to medical institutions for adjustment according to the patient's condition.

Utilizing the advantages of the rapid development of China's Internet platforms, this paper suggests assisted rehabilitation technologies for geriatric robots based on Internet cloud remote measurement and control adjustment services. In the process of rehabilitation training, various sensors are used to obtain patients' physiological information such as heart rate, myoelectricity, muscle tone, respiration, and blood pressure measurements. After the data are sent to the control terminal through Bluetooth, the control terminal transmits the information to the cloud database through a transport layer network. Once the data are processed, the rehabilitation physician remotely adjusts the control parameters of the rehabilitation robot accordingly [7]. The use of cameras or sensors, such as inertial sensors and six-axis sensors,

and machine learning classification algorithms, such as support vector machines (SVM) [8], neural network [9], and deep learning [10], can help physicians analyze patients' gait. Gait disorders occur in joint or spinal arthritis (in patients with distorted musculoskeletal systems) and in patients with central nervous system disabilities resulting from strokes. Through remote electromechanical measurement and control and timely linkage with on-site maintenance personnel, combined with the advantages of traditional Chinese medicine for chronic disease diagnosis and treatment, the quality of diagnosis and treatment are effectively improved, and the effectiveness of the "medical and nursing care smart linking" system is more fully reflected. Therefore, the AI cloud service-based assisted rehabilitation technology for geriatric robots has important research and application value.

3.2.3 AI and opto-mechanical biological effects comprehensive auxiliary diagnosis and treatment technology

PD is a common neurodegenerative disease with an incidence of about 4% in Western Europe. In recent years, with the increasing aging of the Chinese population, PD has leapt to third place among the causes of death among middle-aged and elderly people. Early clinical diagnosis is crucial for the treatment of PD, though it is difficult to diagnose, the honeymoon period of the treatment is short, and the side effects are substantial. Early diagnosis of PD with assistance from wearable devices and remote AI cloud services is an important task for practical research. Deep brain stimulation (DBS) is a new type of treatment for patients with PD that aims to achieve therapeutic purposes by stereoscopically locating and implanting a stimulating electrode at a specific target in the brain. Physicians determine the optimal settings for DBS by clinically testing different combinations of various stimulation parameters. However, choosing the best stimulation parameters not only is difficult and time-sensitive but also requires frequent adjustment [11]. Sensors and machine learning techniques can be employed to easily adjust the electro-acupuncture parameters and improve the quality and efficiency of postoperative rehabilitation.

In-depth research into diagnosis and treatment with DBS in patients with PD using wearable devices and remote AI cloud services is of great significance. The research in this area mainly includes two contents, which are discussed below.

On one hand, studies have investigated the parameters required by AI to remotely utilize wearable devices to assist doctors in optimizing DBS operations. This work has also investigated the postoperative implementation of remote electrical and optical signals to adjust DBS parameters as well as managing drugs and other rehabilitation methods. This is of great significance for postoperative rehabilitation in hospitals, communities, and families.

On the other hand, the use of lasers and AI technology for large depth and damage-free microscopic imaging and nerve stimulation research and application is also very practical. Gradinaru et al. used optogenetics to explore the neural circuits of PD [12]. Moore used both light and ultrasound to stimulate the cortex to cause electrical signals in cortical neurons [13] and improve patients' motor status [14]. The combination of Internet and AI remote control technologies with these medical developments can more effectively deepen research and promote its application in rehabilitation. In particular, existing electrical or optical stimuli require opening the patients' and model animals' skulls, and most require the insertion of an electrode or fiber into the brain tissue to produce a wide range of lesions. Therefore, it is important to explore a minimally invasive way to stimulate only the cortex rather than the deep striatum of the brain. Through the optimization of cortical stimulation, non-invasive or minimally invasive information directly input into the cortex is expected to achieve bidirectional high-speed communication and AI-adaptive optimization. In combination with the regulation of cortical EEG and the motor cortex on the skeletal muscle, it can effectively regulate the movement of bones outside the body and help people with dyskinesia to regain the ability to exercise freely. This not only has significant implications for diagnosis and treatment technology but also provides a new technology that is more reliable and less invasive for the treatment of PD. Research in this area domestically and abroad has just begun. As basic application research, it can provide important technologies for Internet pension rehabilitation services.

3.2.4 Internet doctor training and evaluation system

At present, problems in primary medical centers include low economic efficiency, low medical service level, and a shortage of medical staff. Therefore, improving the enthusiasm of the relevant medical staff and the level of diagnosis and treatment technology must be considered in the construction of China's elderly care system. In the "medical and nursing care smart linking" elderly care system proposed in this paper, a professional medical staff evaluation system can be formulated according to the situation of medical staff to work at the grassroots level, and the medical technology training system will be realized using the Internet to fully mobilize the enthusiasm of doctors and improve the medical service ability of relevant personnel. Achieving "a base level of talents across hospitals" can help solve the practical problems of primary health care.

4 Conclusions

This paper proposes a "medical and nursing care smart linking" elderly care model that is dominated by large hospitals and supported by Internet and AI technologies. The coordination of large hospitals with rich medical resources can improve diagnosis, treatment, and rehabilitation technologies, allowing elderly patients to obtain more professional care. In addition, the establishment of an Internet-connected information system enables information to be shared professionally, combining genetic

and data specifications and transformed cloud technologies. Advanced technologies such as AI cloud services, VR, wearable smart devices, modern 5G mobile communication, optical and electrical biological effects treatment, Chinese medicine chronic disease comprehensive rehabilitation, and robot-assisted diagnosis and treatment may be integrated into the diagnosis and treatment process and management of geriatric diseases. The complementary advantages of technology and management are of great significance for improving the quality of service for elderly people in China and for building a happy society.

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