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Technological Empowerment and Ethical Constraints: Constructing a Data Governance Framework for Smart Community Elderly Care Services

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Abstract: ***Against the backdrop of healthy aging, smart community elderly care services have made remarkable progress through technological empowerment. However, they have also given rise to ethical issues such as privacy violations in data collection, security risks in data storage, algorithmic discrimination in data use, and unclear data ownership in data sharing. This paper aims to construct a data governance framework based on information ethics and privacy protection theory. It adheres to the principles of legality, fairness, security, transparency, and accountability, clarifies the goals of safeguarding data rights and improving service quality, identifies the government, service providers, community organizations, the elderly, and their families as governance subjects, and establishes a governance mechanism covering the entire process of data collection, storage, use, and sharing. Meanwhile, it proposes implementation paths through technological safeguards, ethical reviews, and the improvement of laws, regulations, and supervision to achieve the coordination of technology and ethics and promote the healthy development of smart community elderly care services.***

Keywords: Smart community elderly care services, Technological empowerment, Ethical constraints, Data governance framework**.**

1. Introduction

With the intensification of global population aging, improving the quality of elderly care services and enhancing service satisfaction have become urgent issues to be addressed. Healthy aging has emerged as a crucial strategy for coping with the challenges of an aging society. Driven by this trend, community elderly care services have come into being. As an extension of primary medical and health services and an indispensable service form for the elderly in their home life, community elderly care services have become an important means of ensuring the physical and mental health and well - being of the elderly. [1]

Smart community elderly care is a new model of elderly care. By applying a variety of intelligent technologies and methods, it integrates existing service resources within the community to provide a series of convenient elderly care services for the elderly in the community, including government services, business services, entertainment, education, medical care, and mutual assistance in daily life. This can better meet the elderly's needs for elderly care and has become an important support for achieving healthy aging [1].

However, while technological empowerment has enhanced the quality of elderly care services, it has also brought a series of data - related ethical issues, such as data privacy breaches, data abuse, and algorithmic discrimination. These issues seriously threaten the data rights of the elderly and restrict the sustainable development of smart community elderly care services. Therefore, constructing a scientific and reasonable data governance framework to balance the relationship between technological empowerment and ethical constraints has become a key task in the development of smart community elderly care services.

2. Technological Applications and Data Flow in Smart Community Elderly Care Services

2.1 Main Forms of Technological Empowerment in Smart Community Elderly Care Services

2.1.1 Internet of Things Technology

The IoT technology enables the real - time collection of the elderly's health and life data through the interconnection of smart devices. Smart wearable devices such as smart bracelets and smart watches can continuously monitor the elderly's physiological indicators, including heart rate, blood pressure, blood glucose, and sleep quality, providing dynamic data support for the elderly's health management. At the same time, environmental monitoring sensors play an important role in the elderly's living environment. Devices such as fall sensors, emergency call buttons, and smoke detectors can perceive the elderly's living status and home safety conditions in real - time. In case of abnormal situations, they can immediately issue alarms and notify relevant personnel for intervention, effectively protecting the elderly's lives.

2.1.2 Big Data Technology

Big data technology provides powerful tools for the storage, analysis, and mining of elderly care data. It can integrate massive elderly care data from multiple sources, such as health data, life data, and service demand data. Through in - depth analysis of these data, it can uncover the potential needs and behavior patterns of the elderly. Based on the results of big data analysis, service providers can accurately predict the needs of the elderly, thereby optimizing and allocating service resources in advance, improving the accuracy and efficiency of elderly care services, and providing more personalized and

attentive services for the elderly.

2.1.3 Artificial Intelligence (AI) Technology

AI is increasingly widely applied in smart community elderly care services, bringing many innovations and changes to elderly care. The emergence of intelligent nursing robots has assisted nursing staff in performing many tedious nursing tasks, such as helping the elderly get up, turn over, eat, and take medicine. This not only reduces the workload of nursing staff but also provides more timely and meticulous daily care for the elderly. In addition, intelligent diagnostic assistance systems use AI algorithms to analyze the elderly's medical images and physiological indicators, providing diagnostic suggestions and references for doctors, improving the accuracy and efficiency of diagnosis, and contributing to the early detection and precise treatment of diseases.

2.2 The Process of Data Flow in Smart Community Elderly Care Services

2.2.1 Data Collection

Data collection is the starting point of data flow in smart community elderly care services and involves multiple channels and methods. Smart devices are one of the main sources of data collection. They use sensors and monitoring technologies to collect the elderly's health and life data in real - time and transmit these data to the data center. At the same time, community workers record the elderly's basic information, service needs, health conditions, etc. during their daily services and enter them into the community elderly care service management system. In addition, some third - party service institutions, such as medical institutions and health management institutions, also conduct data docking with the community elderly care service system to share relevant data of the elderly, aiming to achieve more comprehensive and in - depth services.

2.2.2 Data Storage

The collected data need to be centrally stored and managed to ensure data security and integrity. Generally, the smart community elderly care service system will establish a special data storage center, which uses advanced storage technologies and equipment to store data categorically and backup them regularly. The data storage center formulates strict data management strategies, including data access control, encrypted data storage, data backup, and recovery measures, to prevent data leakage, loss, or damage and ensure the reliability and availability of data.

2.2.3 Data Use

In the data use stage, different entities analyze and process data according to their own needs to optimize elderly care services and improve service quality. Elderly care service providers develop personalized service plans for the elderly by analyzing their service demand data and health data, providing precise nursing, rehabilitation, and health management services. Medical institutions use the elderly's health data for disease diagnosis, treatment plan formulation, and health assessment, improving the quality and efficiency of medical services. In addition, government departments, scientific research institutions, etc. can also use these data for policy - making, resource allocation, and the optimization of the elderly care service system.

2.2.4 Data Sharing

In the process of providing smart elderly care services, it is particularly important to construct a complete "Smart Elderly Care Big Data Platform" to achieve service coordination and resource integration [2].

During data sharing, different entities share relevant data of the elderly according to certain rules and agreements. For example, community elderly care service institutions share the elderly's health data with medical institutions to enable the latter to provide better medical services. Elderly care service providers share the elderly's service demand data with social organizations and volunteer teams to promote the socialization and diversification of elderly care services. However, data sharing also faces challenges such as data security, privacy protection, and data quality. Therefore, it is necessary to establish effective data sharing mechanisms and supervision measures to ensure the legal, safe, and orderly progress of data sharing.

3. Analysis of Data - Related Ethical Issues in Smart Community Elderly Care Services

3.1 Ethical Issues in the Data Collection Stage

In smart community elderly care services, there are many ethical issues in the data collection stage. Smart devices often involve comprehensive monitoring of the elderly's lives when collecting data, which may violate the privacy of the elderly. Some smart bracelets not only collect the elderly's health data but may also obtain their location information. If these data are misused, they will seriously affect the elderly's peaceful life. During the data collection process, due to the limited understanding of technology by the elderly, they may not fully understand the purpose, method, and consequences of data collection, resulting in the formality of informed consent. The instructions for using some smart devices are complex and difficult to understand, making it hard for the elderly to truly know how their data will be processed, which violates the principle of informed consent in ethics.

3.2 Ethical Challenges in the Data Storage Stage

The data storage stage also faces severe ethical challenges. Elderly care data contain a large amount of sensitive information, such as the elderly's health conditions and disease history. Once the storage system is attacked by hackers or experiences a data breach, this sensitive information will be at risk of being stolen and misused. In recent years, many elderly care data breach incidents have drawn widespread public attention, causing great mental stress and potential security threats to the elderly. Different entities may lack unified standards and norms when storing elderly care data, resulting in incompatible data formats and uneven data quality, which affects the effective use of data and increases the difficulty of data management, violating the normative ethical requirements of data management.

3.3 Ethical Issues in the Data Use Stage

Algorithmic discrimination is a prominent ethical issue in the data use stage. Algorithms based on big data and AI may discriminate against certain groups of the elderly when recommending services. Some algorithms may tend to recommend high - end services to the elderly with better economic conditions while ignoring the needs of low - income elderly, violating the ethical principle of fairness and justice. Some service providers may over - mine the consumption data of the elderly for commercial interests, conduct targeted marketing promotions, disrupt the normal lives of the elderly, and may even induce the elderly to make unnecessary purchases, such as "health care" products, leading to unnecessary consumption and item hoarding and damaging the economic interests of the elderly [3].

3.4 Ethical Issues in the Data Sharing Stage

The unclear definition of data ownership is a key issue in the data sharing process. Since elderly care data involve multiple entities, including the elderly, service providers, communities, and medical institutions, there are disputes among all parties regarding the ownership and use rights of the data. This leads to a lack of clear rules and bases for data sharing and easily triggers data disputes. When data are shared among different entities, due to the lack of an effective supervision mechanism, the data may be shared again or misused, making it difficult to effectively protect the data rights of the elderly. Some third - party institutions may use the obtained elderly care data for other commercial purposes without the knowledge of the elderly.

4. Theoretical Basis and Construction Principles of the Data Governance Framework

4.1 Theoretical Basis

The construction of the data governance framework requires a solid theoretical foundation. Information ethics emphasizes the moral attributes of information and pays attention to ethical issues in the processes of information production, dissemination, and use. It provides basic ethical guidelines for data governance in smart community elderly care services, guiding how to respect and protect the information rights of the elderly during data processing. The privacy protection theory provides important theoretical support for data governance, clarifying the principles and methods of protecting personal privacy in the data processing process to ensure that the data privacy of the elderly is not violated. In smart community elderly care services, principles such as the principle of minimizing data collection and the principle of anonymization should be followed to reduce potential threats to the privacy of the elderly.

4.2 Construction Principles

The data governance framework for smart community elderly care services should follow a series of principles. First is the principle of legality. The collection, storage, use, and sharing of data must comply with national laws and regulations to ensure that data processing activities are carried out within the legal framework. When collecting data from the elderly, it is necessary to clearly inform them of the purpose, scope, and use method of data collection in accordance with relevant laws and regulations and obtain their legal authorization. The data governance should also adhere to the principle of fairness, ensuring that all elderly people can equally enjoy the convenience brought by smart community elderly care services and avoiding unfair phenomena caused by improper data processing. In the process of algorithm design and service recommendation, discrimination against specific groups of the elderly should be avoided to protect the rights of each elderly person.

5. Construction of the Data Governance Framework for Smart Community Elderly Care Services

5.1 Data Governance Goals

The goals of data governance in smart community elderly care services are of multiple importance, aiming to comprehensively protect the rights and interests of the elderly and improve the quality of elderly care services. The specific goals include the following core aspects:

Safeguarding the data rights of the elderly: This is the primary goal of data governance, covering a series of basic rights of the elderly, such as the right to privacy, the right to know, and the right to choose. By establishing a complete and rigorous data governance mechanism, it is possible to effectively prevent the illegal acquisition, malicious tampering, abuse, or unauthorized sharing of the elderly's data. Only when the elderly are convinced that their data are secure can they participate in smart community elderly care services with confidence, actively use various smart devices and service platforms, and better enjoy the convenience and well - being brought by smart elderly care.

Improving the quality and efficiency of elderly care services: Data governance provides a solid foundation for the precision and personalization of elderly care services through the effective management and in-depth analysis of data. Through the real - time monitoring and analysis of the elderly's health data, potential health risks can be detected in a timely manner, and targeted preventive health care advice and medical intervention measures can be provided. At the same time, the mining of the elderly's life data and service demand data can help service providers optimize service processes, rationally allocate resources, and achieve accurate service delivery and personalized customization.

Promoting the innovative development of elderly care services: A good data governance framework can provide strong support for the innovation of elderly care services. On the one hand, through in - depth data analysis, new needs, trends, and problems in elderly care services can be discovered, providing directions and ideas for the innovation of elderly care service models and products. On the other hand, the secure sharing and circulation of data can promote collaborative cooperation among different entities, drive the integrated development of the elderly care service industry, and give rise to more innovative elderly care service formats and business models, such as the integration of medical and

elderly care, health - care tourism, and smart elderly care communities, providing the elderly with a more diverse range of elderly care service options.

5.2 Data Governance Subjects

In the governance of smart elderly care communities, the government should clearly define its functional boundaries and actively assume the responsibilities of "ensuring basic services, grasping top-level design, establishing systems, and strengthening supervision", providing basic support and guarantees [5]. On the one hand, it is necessary to improve the laws, regulations, and policy standards for data governance, providing a basis and guidance for data governance, and strengthening supervision and inspection to establish a regular supervision mechanism to ensure the legality and standardization of data governance. On the other hand, it is necessary to increase investment in the research and development of data security technologies, encourage innovation, and enhance the data security protection capabilities.

As the main body of data governance, service providers should establish internal data management systems, standardize data governance processes, and strengthen personnel training. In each link of data collection, storage, use, and sharing, relevant principles and measures should be strictly followed to ensure data security. At the same time, they should actively accept supervision from all parties, regularly publish data governance reports, and enhance transparency and credibility.

Community organizations play a bridging role in data governance. They should deeply understand the needs of the elderly, participate in the formulation of data governance policies, and protect the interests of the elderly. They should also assist in carrying out publicity and education to enhance the awareness of the elderly about protecting their data rights. In addition, community organizations should establish a community-level supervision mechanism to monitor the data processing behaviors of service providers, promptly solve problems in data governance, and promote the smooth progress of data governance work.

5.3 Data Governance Mechanisms

Establishing a sound data collection mechanism is the basis of data governance. When collecting data, the principle of minimization should be followed, and only the necessary data related to elderly care services should be collected to avoid over - collection. Multiple methods should be used to fully explain to the elderly the purpose, method, use, and potential risks of data collection to ensure that the elderly truly understand and voluntarily consent to data collection. A data storage classification management mechanism should be established. Data should be stored categorically according to their sensitivity and importance, and corresponding security protection measures should be taken. Encryption storage technology should be used for sensitive information such as the elderly's health data and financial data to improve data security. A regular data backup mechanism should be established to prevent data loss or damage.

6. Implementation Paths of the Data Governance Framework

6.1 Technological Safeguard Measures

6.1.1 Research, Development, and Application of Data Security Technologies

Continuously increase investment in the research and development of data encryption technologies, access control technologies, data desensitization technologies, etc., and constantly optimize and innovate the application methods and effects of these technologies. Use advanced encryption algorithms to encrypt the sensitive data of the elderly to ensure the confidentiality of data during transmission and storage. Through refined access control technologies, strictly limit the access rights of different user roles to data, achieving the principle of least privilege access. Apply data desensitization technologies to desensitize sensitive information in data under the premise of meeting data usage requirements, reducing the risk of data leakage and providing a solid technological support for data governance in smart community elderly care services.

6.1.2 Application of Blockchain Technology

Actively explore the application of blockchain technology in data governance of smart community elderly care services. Leverage its characteristics such as decentralization, immutability, and high transparency to build a trusted data sharing platform. Through blockchain technology, realize the distributed storage and management of data to ensure the authenticity and integrity of data. Every access and modification of data will be recorded on the blockchain, forming an immutable traceability record, effectively preventing data from being tampered with and misused. At the same time, blockchain smart contract technology can automate and intelligentize data sharing, improving the efficiency and transparency of data sharing, and providing a more secure, reliable, and efficient solution for data sharing.

6.1.3 Data Security Assurance at the Smart Device End

At the smart device end, adopt multiple data security assurance measures to ensure the security of data during collection and transmission. Use secure communication protocols to encrypt data during transmission to prevent data from being stolen or tampered with. Deploy data security protection software on the device side to monitor and prevent malware attacks and data leakage risks in real - time. Conduct regular security inspections and vulnerability repairs on smart devices to promptly address device security issues, ensuring the security of the data collection source and preventing data security risks from the source.

6.1.4 Innovation in Data Governance Technologies and Talent Cultivation

To promote the continuous progress and application of data governance technologies, the government and enterprises should jointly invest to support scientific research institutions and universities in carrying out relevant technology research

and innovation. Encourage researchers to explore new data governance technology methods and application models, strengthen interdisciplinary research cooperation, and promote the in - depth integration of data governance technologies and elderly care service requirements. At the same time, pay attention to the cultivation of data governance talents. By setting up relevant professional courses, training programs, and practice bases, cultivate compound talents who understand both data technology and elderly care service operations, providing sufficient talent support for data governance in smart community elderly care services and enhancing the overall level and capabilities of data governance.

6.2 Construction of the Ethical Review Mechanism

Establish an independent data ethics review committee composed of ethical experts, legal experts, representatives of the elderly, etc. The committee is responsible for conducting ethical reviews of data processing projects in smart community elderly care services, assessing the ethical risks of data processing activities, and proposing improvement suggestions and measures to ensure that data processing activities comply with ethical principles. Before the launch of data collection projects, they must be reviewed and approved by the ethics review committee to ensure that data collection behaviors are legal, compliant, and ethical. Strengthen the ethical training of data processing personnel to improve their ethical awareness and moral standards. The training content includes ethical theory knowledge, laws and regulations, data processing specifications, etc., so that data processing personnel can consciously abide by ethical principles in their work and avoid ethical issues. Regularly organize data processing personnel to participate in ethical training courses and seminars, share ethical cases and practical experiences, and continuously improve their ethical literacy.

6.3 Improvement of Laws, Regulations, and Strengthening of Supervision

In the data governance of smart community elderly care services, improving laws and regulations and strengthening supervision are of crucial importance and are the keys to ensuring the orderly development of data governance.

In terms of improving laws and regulations, the government should accelerate the formulation of a special "Data Protection Law for Smart Community Elderly Care Services", clearly defining the rights and obligations of data subjects, standardizing the entire process of data processing behaviors, and increasing the punishment for data - related illegal acts, covering data collection, storage, use, sharing, destruction, and other links, providing a solid legal basis for data governance. In addition, in accordance with the development of technology and changes in elderly care practices, timely revise laws and regulations to ensure their timeliness and adaptability. It is also necessary to strengthen the publicity and education of laws and regulations, enhance the legal awareness and literacy of various sectors of society, especially elderly care service practitioners, and create a good legal environment.

In the construction of the supervision system, it is necessary to establish and improve a data supervision system, clarify the responsibilities and authorities of each regulatory department, and strengthen the supervision of data governance subjects. Regulatory departments should regularly carry out on - site and off - site inspections, use means such as data auditing and technical testing to identify problems, and order rectification within a time limit when potential hazards are found. For data sharing platforms, establish access and exit mechanisms, strictly review and evaluate their data security, sharing processes, privacy protection, and other aspects to ensure the legal and standardized operation of the platforms. In addition, establish a data reporting mechanism, encourage the public to participate in supervision, and provide rewards and protection for reporting behaviors to form a data governance supervision pattern with the participation of the whole society.

7. Conclusion

The smart community health - care model that combines medical and elderly care has become one of the development directions of China's elderly care cause in the future. By integrating community resources and relying on intelligent construction, it forms an integrated medical - elderly care service chain, providing comprehensive, diversified, systematic, and convenient medical and elderly care services for the elderly population [4].

This paper constructs a data governance framework based on information ethics and privacy protection theory, clarifies governance goals, subjects, and mechanisms, and proposes multi - dimensional implementation paths covering technological safeguards, ethical reviews, improvement of laws and regulations, and strengthening of supervision. By implementing these measures, it is possible to achieve the coordination of technology and ethics, protect the data rights and interests of the elderly, and create a good elderly care service environment.

In the future, with technological innovation and changes in elderly care demands, data governance in smart community elderly care services will face more opportunities and challenges. We need to continuously pay attention to industry trends, study new problems and new trends, improve the data governance system, and enhance governance capabilities. Only in this way can we provide higher - quality, safer, and more personalized elderly care services for the elderly, promote the implementation of the healthy aging strategy, enable the elderly to enjoy a happy old age, and achieve the goals of "ensuring the elderly are provided for, supported, entertained, and living in peace".

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