# Research on the Innovation Path of Service Models in the Smart Elderly Care Industry Empowered by Big Data and AI

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**Abstract:** This paper focuses on the innovation-driving role of big data and AI technologies in the service models of the smart elderly care industry. By analyzing the internal logic and practical demands of technological empowerment, it reveals the pain points of current service models, proposes innovation paths based on data fusion, intelligent decision-making, and scenario reconstruction, and constructs a multi-dimensional guarantee system covering technology, management, and ecology, providing theoretical support and practical guidance for the high-quality development of the smart elderly care industry.

## 1. Introduction

### 1.1 Research Background and Significance

Against the backdrop of the accelerated global aging process, China's population aged 60 and above accounts for 21.1%. The demand for elderly care services presents diversified and personalized characteristics. Traditional elderly care models face challenges such as inefficient resource allocation, delayed service responses, and a lack of risk warnings. The integrated application of big data and AI technologies offers a new paradigm for addressing these difficulties. By constructing an intelligent service ecosystem, it is possible to achieve a transformation from passive responses to proactive prevention and from experience-driven to data-driven approaches, which holds significant strategic value for improving the quality of elderly care services, optimizing resource allocation efficiency, and promoting sustainable industrial development[1].

### 1.2 Research Status at Home and Abroad

Internationally, Japan promotes the development of elderly care robots through its "Society 5.0" strategy. The United States relies on IoT technology to build a remote health monitoring network, while the European Union focuses on the design of elderly-friendly services within the AI ethical framework. Domestic research mainly concentrates on the technological application level, such as health data collection and intelligent device development. However, discussions on deep-seated issues such as the innovation mechanisms of service models and cross-sectoral collaboration mechanisms are still insufficient. Existing research mostly focuses on single technological scenarios and lacks a systematic integration framework, making it difficult to support the reconstruction of industrial-level service models[2].

### 1.3 Research Methods and Framework

This study adopts the literature analysis method, interdisciplinary cross-research method, and system dynamics model to construct an analytical framework of "technological empowerment - model innovation - ecological construction." By sorting out the evolution logic of technologies, it identifies key nodes for service model innovation, proposes innovation paths including data governance, intelligent decision-making, and scenario reconstruction, and designs a multi-dimensional guarantee system covering policies, technologies, and ethics[3].

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## 2. Theoretical Foundations of Big Data and AI Empowering Smart Elderly Care

### 2.1 The Internal Logic of Technological Empowerment

Big data technology constructs digital portraits of the elderly through the fusion of multi-source data (such as medical records, behavioral trajectories, and environmental parameters), providing a data foundation for precise services. AI algorithms (such as machine learning and deep learning) achieve intelligent decision-making in health risk prediction and service demand matching. IoT technology, on the other hand, bridges the connection between the physical and digital worlds, forming a closed-loop system of "perception - analysis - response." The synergy of these three aspects drives the transformation of elderly care services from "experience-dominated" to "data-driven."

### 2.2 The Evolution of Service Demands in Smart Elderly Care

The demand hierarchy extends from basic survival guarantees to higher-level needs such as health management, emotional companionship, and social participation. Specifically, health demands shift from disease treatment to preventive health management; life demands upgrade from basic care to personalized elderly-friendly services; and spiritual demands develop from simple entertainment to social interaction and self-worth realization. Technological empowerment needs to precisely match these dynamic demands and construct a hierarchical and classified service supply system[4].

### 2.3 Driving Factors for Service Model Innovation

At the policy level, national documents such as the "Action Plan for the Development of the Smart Health and Elderly Care Industry" clearly point out the direction of technological empowerment. At the technological level, the improvement of infrastructure such as 5G and edge computing lowers the application threshold. At the market level, the increase in the consumption capacity of the elderly and the narrowing of the digital divide between generations give rise to new demands. At the social level, the miniaturization of family structures and the rise in labor costs strengthen the demand for technological substitution. These four driving forces jointly shape the external conditions for service model innovation[5].

## 3. Analysis of the Pain Points of Traditional Elderly Care Service Models

### 3.1 Mismatch between Service Supply and Demand

Traditional models rely on standardized service packages and have difficulty adapting to the individual differences among the elderly (such as health status, cultural background, and economic capacity). For example, unified meal distribution ignores dietary restrictions for chronic diseases, and fixed activity arrangements fail to meet interest preferences, resulting in a service utilization rate of less than 30% and serious resource waste.

### 3.2 Lagging Risk Warnings and Emergency Responses

The current monitoring approaches in elderly care settings are notably lagging, predominantly relying on labor-intensive manual patrols. This outdated method faces significant challenges in achieving real-time capture of critical emergencies, such as sudden falls or acute medical episodes. Alarmingly, data reveals that for solo-living elderly individuals, the average rescue time following an accident stretches beyond 30 minutes, far exceeding the crucial golden rescue window during which timely intervention can drastically improve outcomes. Moreover, the existing health management framework heavily depends on periodic physical examinations, which fall short in providing dynamic risk assessments tailored to each individual's evolving health status. This static approach inadvertently contributes to a high incidence of complications stemming from chronic diseases, as early warning signs and deteriorating conditions often go unnoticed until they escalate into severe health crises. Therefore, there is an urgent need to revolutionize risk warning and emergency response systems in elderly care to ensure timely, effective interventions that safeguard the well-being and safety of the elderly population.

### 3.3 Inefficient Resource Integration and Collaboration

In the field of elderly care services, a multifaceted ecosystem is constructed by the participation of several key entities, namely medical institutions, communities, and families, each of which holds a pivotal position in safeguarding the well - being of the elderly. Medical institutions serve as treasure troves of critical health data, encompassing comprehensive medical histories, precise diagnostic results, and detailed treatment plans. This wealth of information is indispensable for making well - informed decisions regarding the health management of the elderly, enabling medical professionals to tailor care strategies according to individual needs. Communities, on the other hand, possess an in - depth and nuanced understanding of the life demands of the elderly residing within their boundaries. They are acutely aware of the unique social, recreational, and daily living requirements of each individual or group, which helps in creating a more inclusive and supportive living environment. Families, as the most intimate caregivers, offer daily support, emotional solace, and practical assistance with routine activities, forming the backbone of the elderly's immediate care network. Nevertheless, a pervasive and highly detrimental issue within this ecosystem is the presence of information silos. These silos act as formidable barriers, obstructing the free and seamless flow of information among the different entities. Despite the valuable data held by each party, there is a glaring absence of an effective data - sharing mechanism. Consequently, service discontinuities become a frequent occurrence. For example, when an elderly person goes to a medical institution for a check - up, the community and the family may remain in the dark about the results or any emerging health concerns for an extended period. This lack of communication can result in a fragmented and disjointed approach to care, where each entity operates in isolation, paying little heed to the overall situation of the elderly. Moreover, the process of cross - institutional collaboration is extremely cumbersome and inefficient. When different entities need to collaborate to address a specific issue or provide a comprehensive service, they often encounter a series of bureaucratic hurdles and red tape. The response cycle can stretch over several days, which is completely inadequate for meeting urgent demands. In situations where an elderly person requires immediate medical attention or assistance, such delays can have serious and potentially life - threatening consequences, endangering their health and safety. This inefficiency in resource integration and collaboration not only undermines the overall quality of elderly care services but also squanders valuable time and resources that could be better utilized to enhance the well - being and quality of life of the elderly.

### 3.4 Lack of Service Quality and Regulatory Mechanisms

The current landscape of elderly care services is severely marred by a significant lack of standardization, which has a direct and far - reaching impact on the overall quality of services provided. The standardization level of services is alarmingly low, and this is vividly reflected in the uneven professional qualifications of practitioners in the elderly care industry. There exists a wide and concerning variation in the skills, knowledge, and training levels of those who deliver services to the elderly. Some practitioners may have undergone formal and comprehensive training programs, equipping them with the necessary expertise and competencies to provide high - quality care. However, a substantial number of others may lack the required training and knowledge, leading to inconsistent and sub - standard service delivery. This disparity in professional qualifications creates a situation where the quality of care received by the elderly can vary greatly depending on the individual caregiver or service provider. The assessment of service quality is another area that is riddled with flaws and deficiencies. Currently, it relies heavily on subjective evaluations, which are often influenced by personal biases, emotions, and perceptions. These subjective assessments may not accurately and objectively reflect the actual quality of services received by the elderly. For instance, a family member's positive evaluation of a care service may be based more on emotional attachment or a desire to avoid conflict rather than a rational and objective analysis of the service's effectiveness and professionalism. In terms of regulatory mechanisms, the existing methods are far from sufficient and effective. Regulatory approaches mainly focus on post - event spot checks, which means that problems are often identified only after they have already occurred and caused damage. This reactive approach makes it extremely difficult to prevent issues from arising in the first place

and achieve full - process traceability and control. There are several key indicators in elderly care services that lack real - time monitoring. For example, in meal distribution services, the freshness of ingredients is a crucial factor that directly affects the health and well - being of the elderly. However, without real - time monitoring systems in place, it is challenging to ensure that the ingredients used are always fresh, safe, and of high quality. Similarly, the operational norms of care services, such as the proper way of assisting the elderly with mobility or personal hygiene, are not continuously monitored and supervised. This lack of real - time oversight creates loopholes and vulnerabilities in the service delivery process, making it difficult to eradicate safety hazards and ensure that the elderly receive high - quality, safe, and reliable care services that meet their specific needs and expectations.

## 4. Innovation Paths of Service Models Empowered by Big Data and AI

### 4.1 Precise Service Matching Driven by Data Fusion

Construct a three-tier architecture of "basic data layer - feature extraction layer - service matching layer": the basic layer integrates multi-dimensional data such as medical care, social security, and consumption; the feature extraction layer uses natural language processing (NLP) to extract key features such as health risks and behavioral preferences; the service matching layer achieves dynamic matching between service resources and demands based on collaborative filtering algorithms. For example, automatically match low-sugar recipes, rehabilitation training plans, and regular follow-up services for elderly people with diabetes.

### 4.2 Health Risk Warnings Supported by Intelligent Decision-Making

Develop a multi-modal health monitoring system that integrates terminals such as wearable devices, smart mattresses, and environmental sensors to collect more than 200 indicators in real time, including heart rate, blood pressure, and sleep quality. The risk of cardiovascular and cerebrovascular diseases is predicted using time series analysis, while emergencies such as falls and suffocation are identified through anomaly detection algorithms. The system automatically triggers a three-level response mechanism: primary warnings are pushed to family members, intermediate warnings notify community workers, and advanced warnings directly link to emergency centers.

### 4.3 A Full-Cycle Service Closed Loop under Scenario Reconstruction

Create a "home - community - institution" linked service scenario: deploy intelligent security and health monitoring equipment in the home scenario to achieve risk self-checks and remote assistance; build smart health and wellness centers in the community scenario to provide centralized services such as day care and rehabilitation training; introduce care robots and smart pill boxes in the institutional scenario to improve care efficiency. Achieve information intercommunication between scenarios through a unified data platform, for example, automatically synchronizing home monitoring data to community health records and feeding institutional service records back to home care plans.

### 4.4 A Dynamic and Optimized Service Quality Regulatory System

Establish a regulatory closed loop of "data collection - model evaluation - feedback and improvement": collect service process data (such as response time, operational norms, and user evaluations), use random forest algorithms to build a service quality evaluation model, and generate personalized improvement suggestions. Regulatory authorities achieve tamper-proof service records through blockchain technology, and the public can query service qualifications and evaluation information in real time through mobile terminals, forming a pattern of social co-governance.

## 5. Construction of a Guarantee System for Service Model Innovation

### 5.1 Policy and Standard Guarantees

Formulate the "Smart Elderly Care Service Data Security Specifications" to clarify the permission boundaries for data collection, storage, and sharing; issue the "Smart Elderly Care Equipment

Elderly-Friendly Certification Standards" to regulate product functions and operational procedures; establish a dynamic service qualification rating system and incorporate technological application capabilities into assessment indicators to guide institutions to improve their intelligence levels.

### 5.2 Technology and Infrastructure Guarantees

To ensure robust and efficient operations in elderly care services, a range of strategic technology and infrastructure measures are underway. We will strategically deploy edge computing nodes to minimize data transmission delays, crucial for swift emergency responses and enhancing the elderly's safety. Lightweight AI models are being developed to be compatible with low-end equipment, expanding technology coverage in budget-constrained or simplicity-needed care settings. A dedicated IoT platform for elderly care will be constructed to standardize device access protocols and data formats, breaking down isolated systems and promoting interoperability for a more integrated care experience. Additionally, continuous R&D investment will keep us abreast of emerging technologies like 5G, blockchain, and big data analytics, ensuring our services remain innovative, effective, and responsive to the evolving needs of the elderly population.

### 5.3 Ethical and Legal Guarantees

To uphold the highest ethical standards and ensure legal compliance in the realm of elderly care services enhanced by technology, we will firmly establish the principle of "technology for good." This principle will serve as a guiding beacon, strictly prohibiting any form of algorithm discrimination and excessive data collection that could infringe upon the privacy and rights of the elderly. Furthermore, we will build a robust AI decision-making transparency mechanism, which will meticulously explain the logic behind service recommendations to users, fostering trust and understanding. Additionally, we are committed to improving relevant clauses within the "Law on the Protection of the Rights and Interests of the Elderly," clearly defining the scope of technological infringement liability and providing robust protection for the digital rights of the elderly. By doing so, we aim to create a safe, fair, and legally sound environment where technology serves as a beneficial tool rather than a potential threat to the well-being of our elderly population.

### 5.4 Talent and Organizational Guarantees

To lay a solid foundation for the advancement of smart elderly care services, a comprehensive approach to talent cultivation and organizational collaboration is imperative. Universities should take the lead by introducing specialized majors such as "Smart Elderly Care Service Engineering," which are designed to nurture compound technical talents equipped with both elderly care knowledge and cutting-edge technological skills. Concurrently, it is crucial to conduct targeted AI skills training for in-service personnel, thereby enhancing the digital literacy and technological proficiency of service teams, enabling them to better meet the evolving needs of the elderly. Moreover, to foster innovation and expedite the practical application of technological advancements, elderly care institutions and technology companies should be encouraged to jointly establish laboratories. These collaborative platforms will facilitate the seamless integration of research findings into real-world elderly care scenarios, accelerating the transformation and application of technological achievements and ultimately elevating the quality and efficiency of elderly care services.

## 6. Challenges and Future Prospects

### 6.1 Real-world Challenges

In the practical implementation of smart elderly care services, a multitude of challenges have surfaced that demand urgent attention and strategic solutions. Foremost among them is the glaring contradiction between the imperative for data privacy protection and the growing demands for data sharing to enhance service quality. This delicate balance is further complicated by the insufficient digital literacy of the elderly, which significantly restricts their ability to fully benefit from technological applications, leaving them at risk of being left behind in the digital age. Additionally, cross-sectoral collaboration mechanisms remain far from perfect, hindering the seamless integration

of resources and expertise across different domains. Moreover, the high cost associated with cutting-edge technologies poses a formidable barrier to their widespread popularization and affordability, limiting access for a substantial portion of the elderly population. To overcome these hurdles, concerted efforts are required to explore innovative paths, such as leveraging privacy computing technologies to safeguard data while enabling controlled sharing, optimizing elderly-friendly designs to enhance user experience and accessibility, and fostering innovation in government-enterprise cooperation models to drive down costs and promote equitable access to smart elderly care services.

### 6.2 Future Trends

Looking ahead, the landscape of elderly care services is poised for transformative changes across multiple dimensions. At the technological frontier, AI large models are expected to achieve remarkable autonomous evolution in service scenarios, dynamically adapting and optimizing care protocols based on real-time data. Digital twin technology will revolutionize elderly health management by constructing virtual health records that mirror an individual's physical condition, enabling proactive and personalized interventions. Meanwhile, brain-computer interfaces will spearhead a revolution in rehabilitation assistance equipment, offering unprecedented levels of precision and control for those in need. On the service front, the paradigm will shift from "human-machine collaboration" to a more harmonious "human-machine symbiosis," where technology seamlessly integrates into daily care routines, enhancing both efficiency and quality of life. Emotional computing technology will play a pivotal role in this transition, providing precise psychological support tailored to the unique emotional needs of the elderly. At the industrial level, an intricate ecological pattern will emerge, encompassing technology providers, service operators, and data service providers, fostering a collaborative ecosystem that drives innovation and efficiency. This convergence of factors is projected to unlock a market space worth hundreds of billions, presenting immense opportunities for growth and development in the elderly care sector.

## 7. Conclusion

Big data and AI technologies inject new impetus into the smart elderly care industry by reconstructing service logic, optimizing resource allocation, and improving response efficiency. The innovation paths and guarantee systems proposed in this study provide a theoretical framework and practical guide for addressing the pain points of traditional models and achieving precise, proactive, and inclusive services. In the future, it is necessary to continuously explore the ethical boundaries of technologies, improve cross-sectoral collaboration mechanisms, and promote the leap from "technological empowerment" to "value symbiosis" in smart elderly care, contributing to the realization of the people's well-being objectives which means "people's livelihood goals" in Chinese) of "elderly care with dignity."

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