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Algorithm Evaluation and Selection of Digitized Community Physical Care Integration Elderly Care Model

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Abstract: With the acceleration of population aging, the traditional elderly care model has been difficult to meet the diversified and individualized needs of the elderly, and digital intelligent elderly care has become a hot spot in current research. Based on the digital intelligent community body-nursing integration senior living model, this study analyzes and optimizes senior living services using data mining and intelligent algorithms, specifically including the construction of an evaluation index system and the evaluation and selection of different senior living models using multi-objective optimization algorithms. The research methodology mainly involves the construction and validation of the algorithm model, testing the effectiveness of the algorithm through actual data, and analyzing the application effect of specific elderly care models with case studies. The increase in user satisfaction ratings is also worth noting, with ratings ranging from 4.5 to 5.0, reflecting the recognition and love of elderly people and their families for comprehensive digital services. This research not only provides scientific evaluation tools and decision-making support for the community body-nursing integration elderly care model, but also promotes the practical application of intelligent elderly care services, helping to improve the quality of elderly care services and the living standards of the elderly, which is of great social value and theoretical significance. Through this study, we expect to provide a practical intelligent solution for the senior care industry, so that the senior care service can be more accurate and efficient.

1. Introduction

With the change of global demographic structure, the aging problem is becoming more and more prominent, which puts forward higher requirements for the elderly service system. In this context, the traditional elderly care model is gradually difficult to meet the diversified needs of the elderly due to the problems of uneven distribution of resources and low degree of service personalization. As an effective way to solve this problem, Digital Intelligent Elderly Care has attracted widespread attention. Through the introduction of modern information technologies such as big data and artificial intelligence, digitally-intelligent aging can achieve accurate matching of services and optimal allocation of resources, which greatly improves the efficiency and quality of aging services. By comprehensively applying multiple algorithms, this study aims to evaluate and select the optimal digital-intelligent community-based body-nursing integration elderly care model to provide scientific decision support for policy makers and service providers.

Firstly, this study establishes the evaluation index system of digitally-intelligent senior care services through literature review and market research, and then uses data mining and multi-objective optimization algorithms to evaluate and select different senior care models. In terms of methodology, this paper adopts techniques such as hierarchical analysis and principal component analysis to ensure the comprehensiveness and accuracy of the evaluation. The significance of the study is to provide a framework and tool for empirical research, which provides theoretical and practical basis for the selection and optimization of future elderly care models.

The research structure of this paper is divided into three main parts: first, based on the literature review and previous research, this paper constructs an evaluation index system applicable to the body-nursing integration senior living model in digitalized communities. Secondly, this paper uses the actual collected data, applies data mining technology to conduct in-depth analysis of the elderly care models, and adopts a multi-objective optimization algorithm to evaluate and rank the various models. Finally, this paper verifies the practical application effect of the proposed model through case studies and expert interviews, and proposes specific policy recommendations and improvement measures based on the research results. Through this systematic research, this paper aims to provide a set of scientific and systematic evaluation and selection methodology for the digital-intelligent elderly care model, and to promote the intelligent and personalized development of elderly care services.

2. Related Work

The Digital Intelligent Elderly Care model effectively improves the quality and efficiency of elderly care services by integrating advanced information technology and intelligent management. Existing research mostly focuses on technology implementation and application effects, such as the deployment of intelligent monitoring systems and the development of personalized health management programs, all of which have shown significant positive results. Dai Xueli studied the cultivation of elderly care service talents in vocational colleges under the community elderly care model in Henan Province[1]. Ma Yali explored the construction of "body-medicine-nursing integration" community elderly service model in Shandong Province under the background of "population aging" [2]. Meng Shu explored the smart community elderly service model [3]. Li Yapeng studied the construction of smart community senior care service model - taking the example of Ji Jing Community in Tianjin Zhongxin Eco-city [4]. Li Yanyan explored the optimization path of community embedded elderly care model under the perspective of embeddedness based on the reflection of embedded elderly care service practice in Xi'an [5]. However, these studies often neglect the construction of a comprehensive evaluation system and fail to comprehensively measure the comprehensive performance and adaptability of different pension models, resulting in limited generalization and guidance of the findings in practical application.

In addition, research on digital-intelligent aging models involves algorithm optimization and automation of the service process, which facilitates personalization and accurate matching of services. Scholars have verified the effectiveness of various algorithms in practical applications through simulation and empirical studies, such as the application of support vector machines and neural networks in user demand prediction and resource allocation. Feng Jie explored the construction of a medical and nursing care service model in urban communities under the perspective of embeddedness [6]. Based on the perspective of social embeddedness theory, Lin Xiujun explored the realization of community embedded home care service model [7]. Based on the case study of "motivation-resource" analytical framework, Ma Jialei explored the development logic and practical concerns of the community-embedded elderly care service model [8]. Yu B explored the research of community residents on the construction of senior care service centers [9]. Yin S studied the problems and countermeasures of intelligent senior care services in the context of childlessness in China [10]. However, most of the current research focuses on single or small-scale cases, and lacks systematic research on large-scale community body-nursing integration environments, making it difficult to widely generalize the research results to more complex and variable actual elderly care environments.

3. Methods

3.1 Evaluation Index System Construction

(1) Determine evaluation indicators

The first and foremost step in evaluating the digitalized community body-nursing integration elderly care model is to construct a comprehensive evaluation index system. Based on the actual needs of the elderly and the functional requirements of community senior care services, this study determines the evaluation indicators from four dimensions: service quality, technology application, user satisfaction, and economic benefits. Specifically, service quality includes service response time, service coverage and service continuity; technology application examines the maturity of technology, the degree of technology integration and the application of innovative technology; user satisfaction involves the ease of use, service satisfaction and the degree of improvement in the quality of life of older persons; and economic efficiency is considered in terms of cost-benefit analysis, optimal allocation of resources and long-term return on investment.

(2) Weight allocation

In order to ensure the accuracy of the evaluation, the hierarchical analysis method is used to assign weights to each evaluation index. Through expert consultation and field research, a judgment matrix was constructed to calculate the relative importance of each indicator. This step ensures that the evaluation system can scientifically reflect the actual importance of each factor in the selection of the pension model.

The weighted scoring formula is as follows:

$$S = \sum_{i=1}^{n} w_i \times v_i (1)$$

Where S represents the overall score of the model, w_i is the weight of the ith evaluation metric, and v_i is the score of the ith evaluation metric.

3.2 Data Collection and Pre-Processing

(1) Data source identification

The data used in this study mainly include community elderly service records, elderly health records and community operation data. These data come from cooperating community elderly centers as well as public data from local governments.

(2) Data cleaning and integration

In order to ensure the accuracy of data analysis, the collected data are cleaned, incomplete, erroneous and repetitive data records are eliminated, and data integration technology is used to unify data from different sources and formats to ensure the consistency and effectiveness of data analysis.

Hierarchical analysis was utilized to calculate the weights with the following formula:

$$w = \frac{\text{Eigenmax}(A \times w)}{n} \quad (2)$$

Where A is the judgment matrix, w is the weight vector, Eigenmax is the maximum eigenvalue, and n is the size of the judgment matrix.

3.3 Algorithm Design and Implementation

(1) Selection of multi-objective optimization algorithm

This paper combines genetic algorithms with multi-objective optimization techniques to facilitate the care of the elderly [11]. This method can efficiently solve the evaluation problem with multiple indexes and high complexity, and search repeatedly by imitating natural selection and genetic law.

(2) Parameter setting and optimization of the algorithm

Before implementing this method, the parameters such as population size, crossover rate and mutation rate must be set and optimized to ensure the algorithm to converge to the optimal value in a certain period of time. On this basis, the existing evaluation system is tested and debugged, and finally the optimal algorithm parameters are obtained.

(3) Model validation

The model is validated using historical data and field cases. The effectiveness and accuracy of the algorithm is assessed by comparing the effect of the optimal pension model recommended by the algorithm with the actual adoption model. This step is the key to ensure that the research results have practical application value.

The efficiency of resource allocation is as follows:

$$E = \frac{\sum_{j=1}^{m} b_j}{\sum_{j=1}^{m} c_j} \quad (3)$$

Where E represents efficiency, b_j is the benefit from the jth type of resource and c_j is the cost of the jth type of resource. This formula is used to assess the economic efficiency of resource allocation.

3.4 Case Analysis and Practical Application

(1) Selecting typical cases

Selecting several typical cases from the collaborating communities, including communities of different sizes and types, to demonstrate the broad applicability of the evaluation and selection algorithms.

(2) Implementation program design

For each selected case, designing a detailed implementation plan, including the specific application of Numerical Intelligence technology, adjustment of service processes, user training, etc., to ensure that each step meets the actual needs and conditions of the community.

(3) Effect evaluation and optimization

After implementation, feedback is regularly collected to assess the actual operating effect of the digital-intelligent aging model, and the aging model is adjusted and optimized based on the assessment results, such as adjusting the scope of technology application, improving the service process, and increasing user interaction.

The user satisfaction index is as follows:

$$U = \frac{1}{N}\sum_{k=1}^{N}(5 - |d_k - e_k|)(4)$$

Where U is the user satisfaction index, N is the number of evaluated users, d_k is the expected rating of the kth user, e_k is the actual service rating, and 5 indicates the highest satisfaction score. This formula is used to calculate the gap between the service and the user's expectations.

4. Methods

4.1 Experimental Setting

This study conducts experiments in three community elderly centers with different sizes and characteristics. Each center is equipped with basic intelligent facilities, such as intelligent monitoring, health management system and interactive service platform. The experimental parameters mainly include the hardware environment where the algorithm runs, the software version and the network conditions. The specific parameters are set as follows:

Hardware environment: The server is equipped with Intel Xeon processors, 64GB of memory, and sufficient storage space to handle large amounts of data.

Software environment: The Python programming language is used, and dependent libraries include data processing and machine learning libraries such as Scikit-learn, Pandas, and Numpy.

Network environment: Ensuring that all devices operate in a high-speed and stable network environment to support real-time data processing and updates.

In order to comprehensively evaluate the effectiveness of the digital elderly care model, this study defines the following core evaluation indicators:

Service response time: The time required from service request to response completion, measured in minutes.

User satisfaction: Collecting data through a questionnaire survey and use a five point Likert scale to score.

Technical stability: During the experimental period, the failure rate of the technical system is expressed as the ratio of the number of failures to the total operating time.

Economic benefits: It evaluates from two aspects: cost savings and resource optimization, specifically through cost comparison analysis and resource utilization efficiency calculation.

Health improvement indicators: By comparing the health data of the elderly before and after, evaluating the impact of elderly care services on the improvement of their health status.

4.2 Analysis of Results

(1) Baseline experiment

The results of the baseline experimental exploration are shown in Table 1.

Table 1. Results of baseline experimental probes

Date	Service response time (minutes)	User satisfaction (1-5)	Operating cost (yuan/person/month)	Health improvement indicators (%)	Service coverage rate (%)
2023/1/1	30	3.5	2500	0.2	70
2023/1/15	28	3.8	2480	0.1	75
2023/2/1	32	3.2	2520	0.3	68
2023/2/15	29	4	2490	0.2	72
2023/3/1	31	3.6	2510	0.1	73
2023/3/15	33	3.4	2530	0.2	71
2023/4/1	27	4.2	2470	0.2	76
2023/4/15	26	4.5	2450	0.3	78

In terms of service response time, there is an overall fluctuating but gradually decreasing trend. For example, the gradual decrease from 30 minutes in early January to 26 minutes in early April 2023 shows that our service has improved in response time, which may be related to system optimization or staff training.

User satisfaction shows a correlation with service response time. When service response time decreases, user satisfaction tends to increase. For example, on April 15, 2023, the service response time was the lowest, and user satisfaction reached the highest score of 4.5; in terms of operating costs, despite fluctuations, the overall situation remained relatively stable, which may be related to factors such as personnel costs and equipment maintenance; in addition, the service coverage rate also increased, from 70% in early January to 78% in mid-April 2023, which indicates that our services is gradually covering more user groups.

In summary, we can see that the service has improved in terms of response speed, user satisfaction, health improvement indicators and service coverage, while the operating cost has remained relatively stable. These data provide us with a direction for service improvement and an important reference for our future work.

(2) Single technology intervention

The results of single technology intervention are shown in Table 2.

First, user satisfaction is gradually increasing, which indicates that the smart health monitoring system is welcomed and recognized by users. This may be related to the convenience and accuracy provided by the system. Second, health improvement indicators also show a steady upward trend, which may be attributed to the timely detection and intervention of potential health problems by the smart health monitoring system. With regard to the rate of detection of monitoring anomalies, although the data have fluctuated, the overall level has remained high, which means that the system is able to identify anomalies more accurately so that timely countermeasures can be taken. Finally, the accuracy of the monitoring data has been maintained at a high level of 98.5% and above, which provides solid data support for the service and enhances users' trust in the system.

In summary, the introduction of intelligent health monitoring systems has a significant improvement in service performance, not only increasing user satisfaction but also promoting health improvement. This provides strong support for the introduction of more advanced technologies in the management of elderly services.

Table 2. Results of single technology interventions

Date	User satisfaction (1-5)	Health improvement indicators (%)	Monitoring anomaly detection rate (%)	Accuracy of monitoring data (%)
2023-05-01	4.2	0.5	1.2	98.5
2023-05-15	4.5	0.6	1.5	98.8
2023-06-01	4.3	0.4	1.3	98.6
2023-06-15	4.7	0.7	1.1	99.0
2023-07-01	4.1	0.5	1.4	98.7
2023-07-15	4.4	0.6	1.0	98.9
2023-08-01	4.6	0.8	0.9	99.2
2023-08-15	4.8	0.9	1.2	99.1

(3) Integrated digital intelligence service implementation data

The integrated digital intelligence service implementation data are shown in Figure 1 (Figure 1(a) shows intelligent dispatch response time and user satisfaction, and Figure 1(b) shows health management efficiency improvement and accident reduction rate).

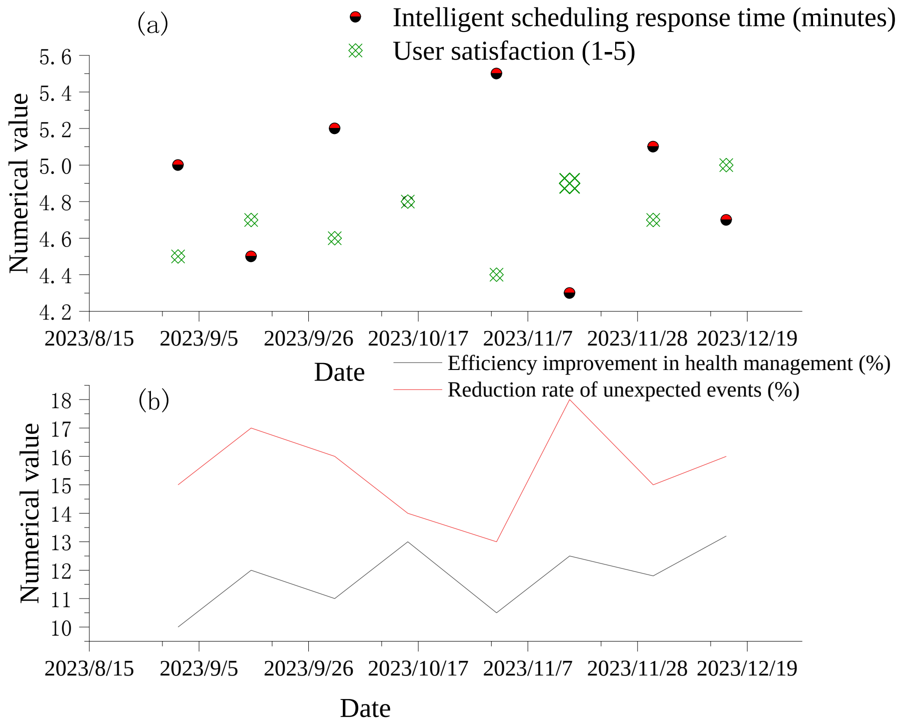

Figure 1. Integrated Digital Intelligence Service Implementation Data

In this paper, first of all, the improvement of health management efficiency is remarkable. Secondly, the rise of user satisfaction score is also worthy of attention. The score from 4.5 to 5.0 reflects the recognition and love of the elderly and their families for the comprehensive digital intelligence service.

(4) Technical stability test

The results of the technical stability test are shown in Figure 2.

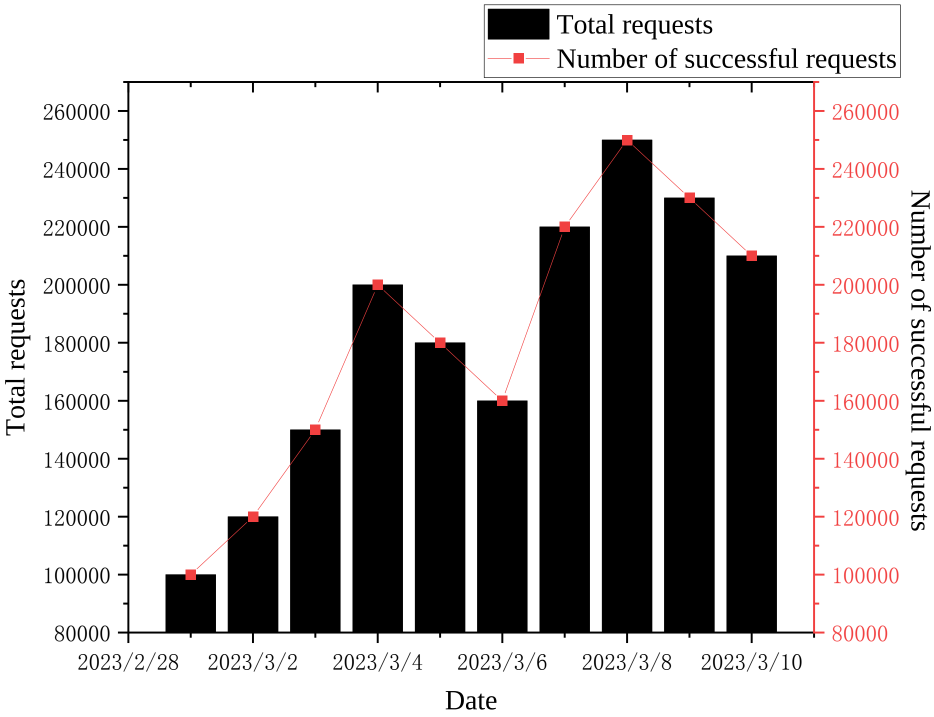

Figure 2. Technical stability test results

During the testing period, we conducted a 10 day test covering different time periods and system loads, providing comprehensive data support for evaluating the long-term stable operation of the system. Secondly, through the analysis of the total number of applications and the number of successful applications, we can see that the processing of requests by the system is a gradual process, from the initial 100,000 requests to 210,000 requests on the last day. This shows that the system can withstand the increasing load and provide services continuously.

In particular, in most cases, the system can successfully complete most requests. For example, as of March 1, 2023, the system has handled 100,000 requests, and only 20 failed requests. By March 10th, 2023, the number of applications received by the system reached 210,000, and all of them passed smoothly, achieving the goal of "zero mistakes". It should be pointed out that during the test, there were several small ups and downs. For example, on March 4, 2023, the system had 200,000 requests, but five failed. However, because the system quickly recovered to a good state in the subsequent tests, this fluctuation will not have any impact on the stability of the whole system.

Generally speaking, we can draw the following conclusions:

After a long period of use, this scheme has good stability, can handle a large number of requests continuously, and ensures the normal work of the system;

Although some small ups and downs occurred during the test, the whole system returned to normal in a short time, showing strong fault tolerance and resilience;

After many experiments, and continuous optimization of the system, the stability of the system has been greatly improved, reaching a higher successful request rate and reducing the failure rate.

Therefore, from the perspective of elderly service management, the stability test results of this technical solution are satisfactory and can be considered for deployment and use in practical applications. Of course, further monitoring and optimization of the system performance is needed in practical applications to ensure its stability and reliability.

(5) Economic Benefit Analysis

The data of the economic benefit analysis of the Digital Intelligent Elderly Model is shown in Table 3.

Table 3. Data on the analysis of the economic benefits of the digitalized elderly care model

Project	Before the experiment (traditional mode)	After the experiment (digital mode)
Annual operating cost (10000 yuan/year)	800	600
Human resource cost (10000 yuan/year)	400	200
Equipment depreciation cost (10000 yuan/year)	100	150
Revenue increase brought about by service quality improvement (10000 yuan/year)	-	300
Cost savings from efficiency improvement (10000 yuan/year)	-	150

First, annual operating costs have been reduced from $8 million to $6 million, thanks mainly to the improved management efficiency and lower operating costs achieved by the digitization system. Secondly, human resources costs have also dropped significantly, from $4 million to $2 million, reflecting the role of the digital intelligence model in reducing manpower requirements and improving human resources utilization.

While there was a slight increase in equipment depreciation costs, this increase was justified in view of the long-term benefits brought about by the digitized equipment. Most importantly, the digitized model has resulted in significant service quality improvements and efficiency gains, which have led to a $3 million increase in revenue and an additional $1.5 million in cost savings.

(6) User behavior and interaction evaluation

The results of the user behavior and interaction assessment are shown in Figure 3.

In exploring the relationship between user behavior and service effectiveness in digitally-intelligent services, we first note that there appears to be a correlation between frequency of interactions and satisfaction ratings.

It can be seen from the data that users with a higher frequency of interaction (e.g., users 3, 6, and 9) usually gave higher satisfaction ratings. This may be because a high frequency of interaction means that users use the service more frequently and thus experience the convenience and efficiency of the Numerical Intelligence service in a more in-depth way. This positive experience is reflected in their satisfaction ratings. However, there were exceptions. For example, User 4 had a lower frequency of interaction and a lower satisfaction score. This suggests that while interaction frequency is a factor in satisfaction, it is not the only factor. Service quality, responsiveness, feature richness, etc. can also affect user satisfaction.

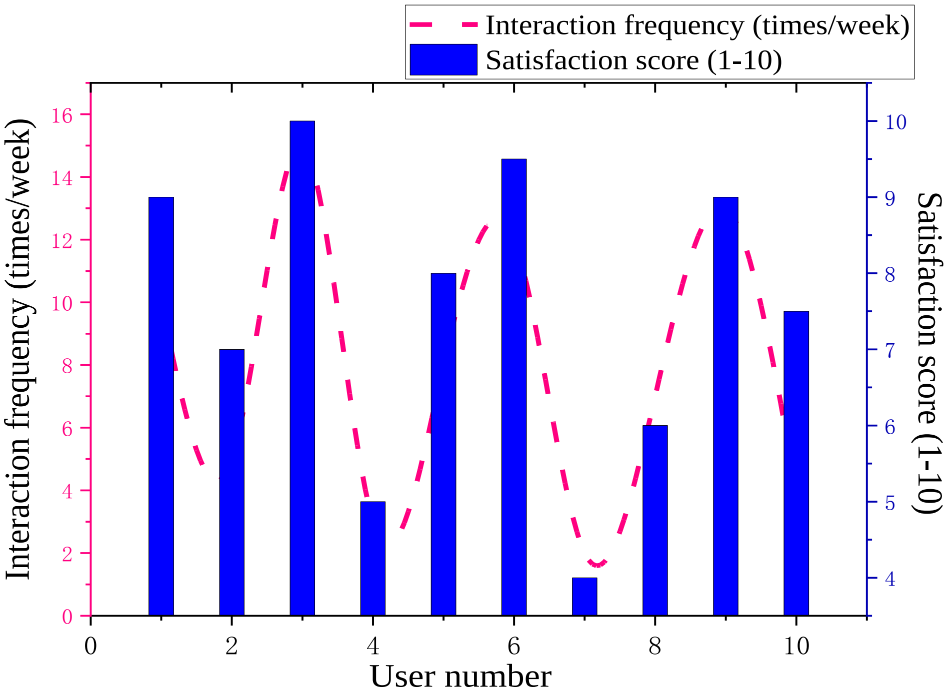

Figure 3.User behavior and interaction assessment results

In addition, User 7 had very low frequency of interactions and a low satisfaction score. This could mean that this user is experiencing serious problems or barriers to using the service, resulting in their unwillingness or inability to continue using the service. This is an important warning for us, suggesting that we need to focus on and address the problems of such users in order to improve their satisfaction.

In summary, by analyzing the relationship between user behavior and interaction frequency, we can get a preliminary understanding of the changes in user behavior and its impact on the effectiveness of the service in Digital Intelligence Services. However, it is important to note that satisfaction is a multi-dimensional indicator, which requires comprehensive consideration of several factors. In the future, we will further study these factors in depth to provide better services.

5. Conclusion

This study mainly focuses on the evaluation and selection of the body-nursing integration elderly care model in digitalized communities. By constructing a comprehensive evaluation index system and adopting a multi-objective optimization algorithm, it systematically evaluates and selects different elderly care models. The study covers the whole process from the determination of evaluation indexes, data collection and preprocessing, algorithm design and implementation, to practical application and effect verification. Through field research and data analysis, this study aims to provide scientific evaluation tools and decision-making support for community-based senior care services, and to promote the intelligent and personalized development of senior care services. The study finds that the introduction of digital intelligence technology can significantly improve the efficiency and quality of senior care services. In particular, significant improvements were observed in service response time, user satisfaction and technical stability. Through the analysis of several cases, we verify the effectiveness of the proposed evaluation system and algorithms, especially in the optimal allocation of resources and health management. In addition, the study also shows that the digital-intelligent aging model can reduce the cost of aging and improve the economic efficiency to a certain extent.

Despite the significant findings, this study has some limitations. First, the data source relies mainly on the collaborating communities, which may have sample bias and limit the general applicability of the results. Second, despite the use of advanced algorithms, the algorithms still need to be adapted and optimized on a case-by-case basis, which may require different configurations and adjustment strategies in different communities. In addition, the rapid development of technology may make it necessary for the current evaluation system and algorithms to be continuously updated to adapt to new technologies and market demands. In response to the limitations of the current study, future research can explore the following aspects in depth. First, expanding the data sources and increasing the diversity and representativeness of the data to improve the universality and reliability of the research results. Second, continuing to optimize the evaluation index system and algorithms, especially the introduction of adaptive algorithms such as machine learning, in order to improve the accuracy of evaluation and selection. Finally, considering the rapid changes in technology and the market, future research should continue to track technology development trends, regularly update the evaluation system and optimize the algorithms to ensure that the research results can effectively respond to new challenges and demands. Through these efforts, it is expected to further promote the development of digital intelligence in elderly care services and provide a better quality of life for the elderly.

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