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Research on the Health Economic Burden Compensation Scheme for the Elderly in Multi-Level Medical Security System

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ABSTRACT

With the global aging trend, the elderly now bear a significant health economic burden. This study aims to explore effective compensation methods within a multi-tiered healthcare system for this group, focusing on China's aging society and medical security reform. Despite extensive research, gaps remain in elderly-specific compensation mechanisms. Utilizing health economics and a multi-level medical security framework, this study employs advanced techniques (e.g., machine learning) to assess elderly medical needs and costs, proposing scientific compensation strategies. Expected outcomes include reduced out-of-pocket costs, higher reimbursement rates, and broader insurance coverage, supporting policy formulation. The study also analyzes regional, economic impacts on elderly medical expenditures to ensure fair, efficient compensation.

KEYWORDS

Population aging; Health care for the elderly; Health economic burden; Multi-level health care systems; Predictive models; Machine learning algorithms

1. INTRODUCTION

As the global population ages, China also sees a rising elderly proportion. By 2030, over-60s will comprise 25% of China's population, challenging the medical security system. Elderly people, with physiological decline and more chronic diseases, consume significant medical resources, drawing societal attention to their health and economic burdens. Population aging reshapes healthcare demand and sets stricter standards for the healthcare system [1]. In this situation, how to design a multi-level medical security framework that can meet the specific needs of the elderly and has financial feasibility has become an urgent issue to be answered. Based on this social background, this study hopes to explore health and economic burden alleviation strategies that meet the characteristics of the elderly population.

Designing a special compensation scheme for the elderly is crucial for practical and social benefits. It can ease economic burdens, enhance elderly quality of life, promote social justice, prevent disease-related poverty, maintain social stability, and support China's medical security system reform, aligning with the healthy China vision.

Research on old age medical security has made strides globally, focusing on policy, cost control, and model comparisons. Western countries have deep Medicare research, while China focuses on urban/rural insurance systems and commercial supplements. However, few studies address designing compensation mechanisms for the elderly, lacking systematic frameworks and technical support. Big data and machine learning for personalized elderly care are still emerging. This study aims to innovate and address evolving social needs. .

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2. THEORETICAL BASIS AND CONCEPTUAL FRAMEWORK

2.1. Overview of Multi-Level Medical Security System

A multi-level medical security system is a medical security system that is led by the government, combined with market participation, social mutual assistance and individual responsibility, and covers the whole people. It includes: basic medical insurance, which is the most basic layer, covering basic medical insurance for urban workers and basic medical insurance for urban and rural residents, aiming to provide basic medical service guarantee for all citizens; Supplementary medical insurance, as a supplement to basic medical insurance, including enterprise supplementary medical insurance, commercial health insurance, etc., to meet the diversified medical needs of different groups; Medical assistance, a backstop guarantee for the poor and those with special difficulties to ensure that they have access to the necessary medical services; Charitable assistance and social donations, non-profit organizations and individuals support vulnerable groups to obtain medical help through donations and other forms.

Each level complements and supports each other, forming a complete medical security network. Basic medical insurance plays the role of wide coverage and basic protection; The supplementary medical insurance improves the guarantee level to some extent and reduces the burden on individuals. Medical assistance and social charity assistance are important supplements for low-income groups and special difficulties, forming the "last line of defense." This multi-tier architecture not only greatly improves the overall robustness of the system, but also optimizes resource utilization and service quality.

2.2. Principles of Health Economics and Their Applications

Health economics hopes to explore strategies and methods to achieve optimal health benefits under the condition of limited health resources. The accounting of the medical cost of the elderly group should consider multiple factors such as age composition, disease type distribution, regional economic development stage and individual economic conditions [2]. This study will use cost-benefit analysis (CBA), cost-effectiveness analysis (CEA) and other methods, combined with actual data, to establish a suitable medical cost assessment model for the elderly population.

Based on the principles of health economics, compensation programs should be designed with the following principles in mind: equity, ensuring that all seniors have equal access to health care services, regardless of their financial status; Effectiveness, by optimizing the allocation of resources, so that each unit of investment can produce the maximum health benefits; Sustainability, taking into account the need for financial affordability and long-term development, avoiding excessive consumption of public resources; Incentivize compatibility, encourage medical institutions to improve service quality, and guide patients to seek reasonable medical treatment.

2.3. Prediction Model Construction

In order to accurately predict the future medical needs and costs of the elderly, this study will use Random Forest Regression (RFR) and Support Vector Machine (SVM) in the machine learning algorithm. Random forest regression (RFR) and support vector machine (SVM) are both very influential machine learning algorithms, which are characterized by excellent generalization performance and effective processing ability for high dimensional data. Ideal for complex medical data analysis. In addition, we will introduce Time Series Analysis to better capture trends in elderly healthcare costs over time.

Random Forest Regression (RFR) is an ensemble learning method that improves prediction accuracy and controls overfitting by building multiple decision trees and averaging their results [3]. Each decision tree is trained on a random subset of the training data, and only a random subset of the

features is considered when each node splits. For a given data point χ, the predicted value y^ of the random forest regression model is the average of all tree outputs:

$$\hat{y} = \frac{1}{T} = \sum_{t=1}^{T} f_t\,(x) \tag{1}$$

Where T is the number of trees in the forest and f$f_t(x)$is the predicted value of the t th tree for the input x.

Prediction of a single tree: Each decision tree f_t (x) is the prediction of the input x depends on the path selection from the root to the leaf node, and finally returns the output value corresponding to the leaf node.

Support Vector Machine (SVM) is a supervised learning model that is widely used in classification and regression tasks [4]. SVM tries to find a hyperplane so that samples of different classes are separated as far apart as possible, and this partition has the greatest spacing. For nonlinear problems, the original space can be mapped to a high-dimensional feature space by the kernel trick, where a linearly separable solution can be found. For a binary classification problem, SVM aims to minimize the following objective functions:

$$\underset{wb\ \in}{min}\left(\frac{1}{2}\|w\|^2 + c\sum_{i=1}^{N} \in_i\right) \tag{2}$$

At the same time meet the constraints:

$$y_i(w \cdot \phi(x_i) + b) \geq 1 - \in_i,\ \in_i \geq 0,\ \mathrm{i} = 1 \ldots,\ \mathrm{N} \tag{3}$$

Where w is the weight vector, b is the bias term, $\in_i$is the relaxation variable allowing for some degree of misclassification, c is the tradeoff between the complexity and error of the model controlled by the regularization parameter, $\phi(x)$ is a function mapping the input space to a higher-dimensional feature space, $y_i \in \{-1,\ +1\}$ is the label, and $x_i$is the input sample.

Decision function: For the new input x, the SVM's prediction is given by the following decision function:

$$\mathrm{f}(x) = sign(\sum_{i=1}^{N} \alpha_i y_i\, K(x_i,\ \ x) + b) \tag{4}$$

Where α_i is the Lagrange multiplier, and $K(x_i,\ x)$ is the kernel function that defines the similarity between two samples. Common kernel functions include linear kernel, polynomial kernel, RBF (radial basis function) kernel and so on.

By learning from historical medical data, the predictive model can estimate the potential medical expenditure of each elderly person over a period of time in the future and adjust the compensation scheme based on these predicted results [5]. For example, for the elderly with chronic diseases, early intervention can reduce the high medical costs that may occur in the future; For sudden diseases, an emergency rescue mechanism should be established to ensure timely treatment. This not only helps to reduce the economic pressure of individuals and families, but also helps to optimize the efficiency of the entire medical security system.

3. ANALYSIS OF HEALTH ECONOMIC BURDEN OF THE ELDERLY

3.1. Status Description

Using stats from the National Bureau of Statistics and Health Commission, combined with sample surveys, this study used descriptive stats and regression analysis to detail elderly health and medical expenses. Key diseases include cardiovascular disease, diabetes, chronic respiratory issues, and cancer, rising with age, impacting quality of life and increasing medical costs. Hospitalizations are up, especially for those with multiple chronic conditions. Frequent medical visits are needed for disease management, with elderly outpatient visits exceeding those of younger groups.

Due to the different level of economic development and the distribution of medical and health resources among different regions, the medical expenditure of the elderly population presents a great difference. For example, in the developed areas of the eastern coast, due to the relatively complete medical service system and sufficient medical personnel, the medical expenses of the elderly are generally high. In the less developed regions of central and western China, although the medical cost is relatively low, some complex diseases may not be diagnosed and treated in a timely and effective manner due to local medical conditions. In addition, the economic status of individuals or families is also an important variable affecting the medical expenditure of the elderly. Families with superior economic conditions can undertake more self-funded medical projects and further enjoy better quality medical services. In contrast, families with poorer economic conditions are more dependent on basic health insurance and social assistance and often bear a heavier financial burden.

3.2. Problem Identification

Although China has built a relatively complete multi-tiered medical security system, in practice, the elderly still have to bear a fairly high proportion of personal expenditure. Especially in the face of some expensive drugs, specific tests and treatment items, due to the limitations of insurance coverage, many elderly people have to bear the high medical costs. Not only do older people suffer physical discomfort when they fall ill, but family members also face additional time costs and financial pressures to care for them. The burden is even greater if there are multiple elderly patients in a family. At a certain level, the existing medical insurance policies are still unable to fully meet the actual needs of the elderly. For example, the funding for non-acute medical items such as rehabilitation nursing and long-term care is relatively weak, resulting in such expenses being mainly borne by individuals, which further aggravates the economic burden of families. In addition, the quality and accessibility of medical services among different regions also show a large imbalance, especially in remote areas, the elderly group faces great challenges in obtaining high-quality medical services. Even within the same city, there are obvious differences in the service efficiency of different levels of medical institutions, which has a direct impact on the process of seeking medical treatment for the elderly.

4. DESIGN OF COMPENSATION SCHEME FOR THE ELDERLY UNDER MULTI-LEVEL MEDICAL SECURITY SYSTEM

4.1. Goal Setting

In order to effectively alleviate the health and economic pressure of the elderly, this study hopes to build a scientific and feasible compensation mechanism, its core objectives cover. By optimizing the medical insurance policy and introducing diversified support means, the proportion of direct payment of the elderly and their families can be reduced to further ease their economic burden. Increase the reimbursement limit of medical insurance and expand its application areas, with special emphasis on non-emergency medical services such as chronic disease management and long-term care. Further

expand the coverage of medical insurance, increase the types of reimbursement for basic drugs, diagnosis and treatment items, and ensure that the elderly can enjoy comprehensive medical security.

To measure the effectiveness of the compensation package, we will establish the following key performance indicators: the rate of out-of-pocket cost reduction, which assays the decline in the share of medical expenses paid by older persons individually; The increase in reimbursement coverage, which measures the number and impact of newly added services or items covered by Medicare reimbursement; Satisfaction survey results: Through questionnaire survey, the recognition degree and satisfaction degree of the elderly and their families to the new compensation program were collected; The fiscal sustainability index ensures that compensation schemes provide better protection without placing undue pressure on public finances.

4.2. Strategy Making

Optimize the reimbursement system structure and adjust the current reimbursement rate, especially to increase the reimbursement rate for those treatments with higher costs and greater efficacy. Non-acute medical items such as rehabilitation nursing, long-term care and assistive devices will gradually be included in the reimbursement scope of medical insurance. Streamline the reimbursement process and cut redundant approval procedures so that seniors can enjoy health insurance services more easily. Cooperate with insurance companies to develop commercial health insurance products specifically for the elderly group to provide personalized protection options. For low-income elderly families, the government can encourage them to buy commercial supplementary insurance through financial subsidies to further share the risk. Exploring the cooperation mode of the government and commercial insurance companies to jointly bear risks not only guarantees the rights and interests of the elderly, but also promotes the healthy development of the commercial insurance market.

We will raise funds through various channels such as financial allocation, social donations and corporate sponsorship to ensure the adequacy and stability of the special rescue fund. Clear criteria for assistance, giving priority to poor elderly people, seriously ill patients and special groups in need of long-term care. Establish a strict application review system and information disclosure platform to ensure that the rescue process is open and transparent to prevent abuse or misappropriation.

4.3. Application of Prediction Model

Based on the prediction model constructed above, we will use actual data to verify and optimize the model to ensure the accuracy and reliability of its prediction results. For example, by comparing the difference between the predicted value of the model and the actual medical costs incurred, the parameter Settings are constantly adjusted to improve the performance of the model. Using the optimized prediction model, we can simulate the changing trend of the elderly medical expenditure under different compensation strategies, and evaluate the possible economic and social benefits after the implementation of each plan. This helps decision makers to choose the best plan according to the simulation results and take countermeasures in advance, such as adjusting budget allocation and strengthening publicity and promotion.

5. POLICY RECOMMENDATIONS AND FUTURE PROSPECTS

5.1. Policy Suggestion

First, build a cross-departmental collaboration mechanism. Strengthen the synergy between health, civil affairs, finance and other institutions to ensure that the medical security measures of the elderly group can be seamlessly connected with other social welfare policies. Through regular joint meetings and other forms, we will jointly study and solve major problems in the medical security of the elderly. Second, optimize multi-level system coordination: further clarify the functional positioning and

responsibility sharing of basic medical insurance, supplementary medical insurance, medical assistance and other levels, form a joint force, and improve the overall level of protection. Third, improve legislative protection: promote the formulation or revision of relevant laws and regulations, clearly specify the rights and obligations of the elderly in terms of medical security, and ensure that their legitimate rights and interests are protected by law. The fourth is to regulate market behavior: strengthen the supervision of the commercial health insurance market, prevent unfair competition and misleading sales practices, and safeguard the interests of consumers. Fifth, improve the quality of service supply, including: increase the capacity of primary medical services, increase investment in community health service centers and township health centers, improve infrastructure conditions, train professional medical personnel, so that the elderly can obtain timely and effective medical services at the local level; We will promote information construction, use modern information technologies such as big data and cloud computing to build a telemedicine service platform covering urban and rural areas, promote the sinking of high-quality medical resources, and facilitate the elderly to seek medical treatment. Sixth, we will strengthen publicity and education. To promote health knowledge, organize diversified health education activities, enhance the elderly's self-care awareness and disease prevention ability, and further reduce unnecessary medical expenses. The government should widely publicize various kinds of medical security policies for the elderly, ensure that the elderly and their families fully understand their rights and interests, and actively apply for relevant benefits.

5.2. Future Outlook

With the accelerating process of population aging, the needs of the elderly are undergoing changes. Future academic research should continue to focus on this dynamic change, adjust and optimize the current medical security system in a timely manner, and further effectively respond to the challenges caused by the rising proportion of elderly population. The application potential of cutting-edge technologies such as artificial intelligence and Internet of things in the field of elderly health management will be deeply discussed, such as monitoring health status through the development of smart wearable devices to achieve early warning and intervention. According to the specific differences of individuals, a more accurate medical cost compensation mechanism should be developed to meet the unique needs of various elderly groups.At the same time, it is necessary to deeply study the successful experience and failure lessons of foreign developed countries and regions in the aspect of medical security for the elderly, and carry out the localization transformation according to our national conditions, so as to provide a beneficial reference for the improvement of medical security system for the elderly in our country. And actively participate in the relevant projects and exchange activities of international organizations, sharing China's experience while learning advanced management concepts and technical means of other countries.

6. CONCLUSION AND RESEARCH PROSPECT

This study reveals elderly face significant medical security burdens due to aging and chronic diseases, raising personal/family medical expenses. High out-of-pocket costs affect quality of life. Multi-level medical security systems help, but issues like lack of synergy and unequal service quality persist. Proposed compensation schemes include medical insurance adjustments, commercial insurance, and special funds to reduce financial pressure, improve reimbursement, and enhance system fairness/sustainability. Prediction models aid decision-making, but data limitations may affect analysis accuracy. Although the level of economic development and service capacity of different regions are taken into account, the situation may be different for each province or city and more detailed regional studies are needed; More time and data accumulation are needed to assess the long-term effects of compensation programmes in order to fully understand their impact on the quality of life and social stability of older persons. Future research can be further deepened in the following

aspects: To explore how to dynamically adjust the parameters of the multi-level medical security system according to the changes of the elderly population structure and social and economic development, so as to ensure that it is always in the optimal state; Combining the knowledge of economics, sociology, public health and other disciplines to understand and solve the problem of medical security for the elderly from a broader perspective; Conduct long-term longitudinal follow-up surveys to collect more data on the health status of older persons, medical expenditures, etc., to provide a more solid basis for policy formulation; Explore the integration of advanced technologies such as artificial intelligence, big data, and the Internet of Things into the health management and service system for the elderly to improve service efficiency and quality; Based on individual differences, more personalized medical cost compensation programs and service items are developed to meet the specific needs of different elderly groups.

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