Grey Relational Analysis of Changes in Patient Visits and Influencing Factors in Primary Healthcare Institutions in Guangdong Province (Postprint)

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Abstract

Background: China's tiered diagnosis and treatment system has achieved certain progress; however, the development of primary healthcare institutions remains relatively slow. Objective: To analyze the trends and influencing factors of outpatient visits to primary healthcare institutions in Guangdong Province from 2013 to 2020, and to provide evidence for policymakers to deepen the tiered diagnosis and treatment system. Methods: In December 2021, outpatient visit data for primary healthcare institutions were extracted from the Guangdong Province Health Statistical Yearbook (2013-2015), Guangdong Province Health and Family Planning Statistical Yearbook (2016-2017), and Guangdong Province Health Statistical Yearbook (2018-2020) as the reference sequence. Population data and per capita disposable income of residents were obtained from the Guangdong Statistical Yearbook 2021, while fiscal subsidies to primary healthcare institutions and medical insurance enrollment figures were extracted from the China Health and Family Planning Statistical Yearbook (2015-2017) and China Health Statistical Yearbook (2018-2021) as the comparison sequence. Grey relational analysis was employed to evaluate the degree of association between each influencing factor and outpatient visits to primary healthcare institutions. Results: From 2013 to 2019, hospital outpatient visits in Guangdong Province increased from 334.592 million to 401.317 million, representing an average annual growth rate of 3.08%. During the same period, outpatient visits to primary healthcare institutions grew at an average annual rate of 2.10%, reaching 437.317 million in 2019. In 2020, due to the COVID-19 pandemic, outpatient visits to both hospitals and primary healthcare institutions declined significantly. The proportion of primary healthcare institutions in total medical institution outpatient visits decreased from 50.7% in 2013 to 48.1% in 2020. Grey relational analysis revealed that permanent resident population (r=0.913) and population aged 65

and above (r=0.913) exhibited the strongest association with outpatient visits to primary healthcare institutions, followed by the number of participants in urban and rural resident medical insurance (r=0.899), number of beds in primary healthcare institutions (r=0.893), number of primary healthcare institutions (r=0.886), and number of participants in urban employee medical insurance (r=0.872). Conclusion: Currently, many patients still prefer hospital care, and the gatekeeping system at the primary level needs strengthening. In light of population aging, we recommend addressing residents' need for accessible local healthcare through three approaches: expanding the scope of primary healthcare services, widening reimbursement gaps between different levels of medical institutions, and enhancing the service capacity of primary healthcare institutions.

Full Text

Changes in Patient Visits and Associated Determinants in Primary Healthcare Settings in Guangdong: A Grey Relational Analysis

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Abstract

Background: China has made some achievements in the construction of hierarchical medical system, but the development of its primary healthcare settings is still relatively slow. **Objective:** To analyze the changes in patient visits and associated determinants in primary healthcare settings in Guangdong during 2013 to 2020, providing a basis for deepening the construction of hierarchical medical system. **Method:** In December 2021, this study extracted patient visits in primary healthcare institutions of Guangdong from Guangdong Health Statistics Yearbook (2013–2015), Guangdong Health and Family Planning Statistical Yearbook (2016–2017), and Guangdong' s Hygiene and Health Statistical Yearbook (2018–2020) as the reference sequence, and extracted the population data and per capita disposable income from Guangdong Statistical Yearbook 2021, and the financial subsidy for primary healthcare institutions and the number of medical insurance participants from China Health and Family Planning Statistical Yearbook (2015–2017) and China' s Hygiene and Health Statistical Yearbook (2018–2021) as the comparative sequence. Grey relational

analysis was used to evaluate the strength of correlation between the number of patient visits and its potential associated determinants involving demographic and socioeconomic status, health resource allocation and medical insurance participation. **Results:** The number of hospital visits in Guangdong increased from 334.592 million in 2013 to 401.317 million in 2019, with an average annual growth of 3.08%. The number of patient visits in primary healthcare settings in the province reached 437.317 million in 2019, and the average annual growth in these settings was 2.10% during 2013 to 2019. In 2020, the number of patient visits in hospitals and in primary healthcare settings both decreased significantly because of the COVID-19 pandemic. The number of patients visits in primary healthcare settings accounted for 50.7% of all patients visits in medical institutions in 2013, which declined to 48.1% in 2020. Grey relational analysis showed that both the number of residents (r=0.913) and the number of people aged over 65 years old (r=0.913) had the strongest correlation with the number of patient visits in primary healthcare settings, followed by the number of urban-rural resident basic medical insurance participants (r=0.899), the number of beds in primary healthcare settings (r=0.893), the number of primary healthcare settings (r=0.886) and the number of urban employee basic medical insurance participants (r=0.872). **Conclusion:** At present, many patients still flow to hospitals for medical services, which calls for actions to strengthen the first contact in primary care system. It is suggested to meet the needs of residents for nearby medical treatment by enriching the connotation of primary care services, widening the gap of healthcare expenses reimbursed by medical insurance among medical institutions and improving the service capacity of primary healthcare settings under the background of population aging.

Keywords: Hierarchical diagnosis; Primary healthcare institutions; Medical attendances; Grey correlation analysis

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1. Methods

1.1 Data Sources

Patient visit data were extracted from the Guangdong Health Statistics Yearbook (2013–2015) [6-8], Guangdong Health and Family Planning Statistical Yearbook (2016–2017) [9-10], and Guangdong Health and Health Statistical Yearbook (2018–2020) [11-12, 3]. Data on per capita disposable income and population were extracted from the Guangdong Statistical Yearbook 2021 [13]. Data on financial subsidies for primary healthcare institutions and medical insurance enrollment numbers were extracted from the China Health and Family Planning Statistical Yearbook (2015–2017) [14-16] and China Health and Health Statistical Yearbook (2018–2021) [17-20]. In this study, "primary healthcare institutions" include community health service centers (stations), township health centers, clinics, infirmaries, and village clinics.

1.2 Research Methods

1.2.1 Theoretical Basis Cybernetics uses white, grey, and black to describe the degree of information clarity, where white represents completely clear information, black represents unknown information, and grey represents information whose clarity is between completely clear and completely unknown [21]. Grey system theory was first created by Professor Deng Julong [22]. This theory takes grey systems characterized by "small sample, poor information, and uncertainty" as research objects, exploring the evolution laws and development trends of grey systems through mining and analyzing known information [21]. The number of patient visits in primary healthcare institutions is influenced by subjective and objective factors such as residents' medical behavior, health resource allocation, social population characteristics, and medical insurance enrollment numbers. It is a typical grey system where some information is known and some is unknown. Therefore, grey system theory is appropriate for analyzing the influencing factors of patient visits in primary healthcare institutions.

1.2.2 Grey Relational Analysis Method Grey relational analysis compares the correlation degree by the similarity of geometric shapes of influencing factor time series. The closer the geometric shape of the comparison sequence is to that of the reference sequence, the higher the correlation degree between them [23-24]. Traditional linear regression analysis requires data to meet certain standards and follow specific distribution characteristics, while grey relational analysis is not limited by these data conditions. Considering data availability, this study appropriately adopts grey system theory for analyzing influencing factors of patient visits in primary healthcare institutions. The analysis steps are as follows: (1) Determine the reference sequence X_0 and comparison sequences X (i=1,2···m); (2) Use the initial value method or mean value method to non-dimensionalize the original data, obtaining X' $_0$ and X' (i=1,2···m); (3) Calculate the absolute difference Δ between corresponding values of X' $_0$ and X' (i=1,2···m), i.e., the two-level difference Δ (k) = |X' $_0$(k) - X' (k)|, where i=1,2···m, k=1,2···n; (4) Determine the minimum Min and maximum Max of all Δ (k) values, with the resolution coefficient typically taken as 0.5, and calculate the correlation coefficient (Min + Max) / (Δ (k) + Max), where i and k values are the same as in step (2); (5) Calculate the correlation degree r_0 = (1/n) Σ r_0 (k), where i and k values are the same as in step (2).

1.2.3 Selection of Potential Influencing Factors Referencing the explanatory variables selected by the RAND Corporation based on the "one process, four components" theoretical hypothesis of medical service utilization [25], and drawing on the research results of Shen Xiaoyan et al. [26], Rao Keqin [27], and Shi Long et al. [5], combined with data availability, this study takes patient visits in primary healthcare institutions as the reference sequence. Influencing factors were selected from four dimensions: resource allocation (number of primary healthcare institutions, number of beds in primary healthcare institutions, number of health technicians in primary healthcare institutions, number

of practicing (assistant) physicians in primary healthcare institutions, number of registered nurses in primary healthcare institutions), social population characteristics (resident population, proportion of population aged over 65, proportion of population aged 0-14), economic factors (per capita disposable income of urban residents, per capita disposable income of rural residents, financial subsidy income of primary healthcare institutions), and medical insurance enrollment status (number of urban employee medical insurance participants, number of urban resident basic medical insurance participants).

1.3 Statistical Methods

Excel 2016 was used to establish the database, and the mean value method was used for non-dimensionalization of the reference sequence and each influencing factor sequence value.

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2. Results

2.1 Changes in Patient Visits in Guangdong' s Medical Institutions

From 2013 to 2019, the number of hospital visits in Guangdong increased from 334.592 million to 401.317 million, with an average annual growth rate of 3.08%. During the same period, the average annual growth rate of patient visits in primary healthcare institutions in the province was 2.10%, reaching 437.317 million in 2019. In terms of the total number of patient visits in medical institutions in the province, there was a stable growth trend from 2013 to 2019, with the total number of visits increasing to 891.046 million in 2019, representing an average annual growth of 2.69%. In 2020, due to the impact of the COVID-19 pandemic, both hospital and primary healthcare institution visits decreased significantly. However, overall, the proportion of primary healthcare institution visits among all medical institution visits showed a slow downward trend, while the proportion of hospital visits showed a slow upward trend, as shown in Table 1 .

2.2 Influencing Factors of Patient Visits in Primary Healthcare Institutions

This study took patient visits in primary healthcare institutions (X_0, in 10,000 visits) as the reference sequence, and the following as comparison sequences: number of primary healthcare institutions (X_1, in units), number of beds in primary healthcare institutions (X_2, in beds), number of health technicians in primary healthcare institutions (X_3, in persons), number of practicing (assistant) physicians in primary healthcare institutions (X_4, in persons), number of registered nurses in primary healthcare institutions (X_5, in persons), resident population (X_6, in 10,000 persons), population aged over 65 (X_7, in 10,000 persons), population aged 0-14 (X_8, in 10,000 persons), per capita disposable

income of urban residents (X_9, in yuan), per capita disposable income of rural residents (X_{10}, in yuan), financial subsidy income of primary healthcare institutions (X_{11}, in 100 million yuan), number of urban employee medical insurance participants (X_{12}, in 10,000 persons), and number of urban-rural resident basic medical insurance participants (X_{13}, in 10,000 persons). The reference sequence and each influencing factor sequence value from 2013 to 2020 are shown in Table 2 .

2.2.1 Results of Non-dimensionalization The mean value method was used to non-dimensionalize the data in Table 1, with results shown in Table 3 . After non-dimensionalization, the absolute difference between each comparison sequence and the reference sequence value for the same year was calculated. In this study, the minimum absolute difference was 0.001 and the maximum absolute difference was 0.797, as shown in Table 4 .

2.3 Grey Relational Analysis Results

The grey relational degree between each comparison sequence and the reference sequence was calculated and ranked by correlation strength. Higher ranking indicates stronger correlation with patient visits in primary healthcare institutions. The ranking result was $r_6=r_7>r_{13}>r_2>r_1>r_{12}>r_8>r_4>r_9>r_3>r_{10}>r_5>r_{11}$, indicating that the main influencing factors of changes in patient visits in Guangdong' s primary healthcare institutions were resident population (X_6, in 10,000 persons), population aged over 65 (X_7, in 10,000 persons), number of urban-rural resident basic medical insurance participants (X_{13}, in 10,000 persons), number of beds in primary healthcare institutions (X_2, in beds), number of primary healthcare institutions (X_1, in units), and number of urban employee medical insurance participants (X_{12}, in 10,000 persons), as shown in Table 5 .

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3. Discussion

3.1 Declining Proportion of Patient Visits in Guangdong' s Primary Healthcare Institutions

The results show that the proportion of total patient visits in primary healthcare institutions among all medical institutions in the province showed an overall downward trend, decreasing from 50.7% in 2013 to 48.1% in 2020, which is still some distance from the policy target requirement of 65% [2]. This is basically consistent with the research conclusion of Zhou Minghua [2], indicating that the proportion of patient visits among various medical institutions is still not reasonable enough, and medical services have not been well transferred to primary care. Currently, the efficiency of health resource allocation in Guangdong' s primary healthcare institutions has not reached the optimal input-output state. Most township health centers in the province have sufficient or even redundant inputs,

but relatively few medical service outputs such as outpatient and inpatient services [28]. Previous studies have shown that due to information asymmetry between doctors and patients, patients mainly consider medical technology level, medical cost burden, and transportation convenience when choosing medical institutions [32].

3.2 Strong Correlation Between Patient Visits in Primary Healthcare Institutions and Social Population Structure

The results show that both resident population (r=0.913) and population aged over 65 (r=0.913) in Guangdong had the strongest correlation with patient visits in primary healthcare institutions, with very similar development directions and rates, indicating that changes in social population structure are the main cause of changes in patient visits in primary healthcare institutions. Internationally, it is generally believed that when the proportion of population aged over 60 exceeds 10% or the proportion aged over 65 exceeds 7% of the total population, the country or region is in an aging society. Data from Guangdong Statistical Yearbook 2021 show that the proportion of population aged over 65 in the province increased from 7% in 2012 to 8.58% in 2020 [13]. With the deepening of population aging, health problems such as chronic diseases, disability, and depression among the elderly become prominent, and the increased health service demand of the elderly leads to growth in patient visits to medical institutions. Due to the two types of factors, economic development level indirectly inhibits the proportion of patient visits in primary healthcare institutions in China [5]. With the development of society and economy, the improvement of road traffic and other infrastructure has greatly enhanced transportation convenience, and the growth of per capita disposable income has reduced the economic burden of medical treatment to some extent. Since the existing system does not strictly limit first contact at primary care, the possibility of residents seeking medical treatment at higher-level medical institutions increases. The concentration of high-quality health resources in public hospitals caused by China' s administrative system further intensifies the 'siphoning effect' of public hospitals on patients [29]. At the same time, the increase in basic public health service volume in primary healthcare institutions in recent years has occupied the time for providing medical services to some extent, reducing the enthusiasm of primary healthcare personnel to provide medical services [30]. In addition, Guangdong has not yet formulated unified two-way referral standards and procedures. Primary healthcare personnel mostly rely on their own judgment and patients' willingness when implementing referrals, making referral behavior somewhat arbitrary and subjective. Some patients who should be treated at primary care may be referred to higher-level medical institutions, and the unsmooth two-way referral may lead to difficulties in downward referral [31].

3.3 Increased Medical Insurance Enrollment Helps Drive Growth in Patient Visits in Primary Healthcare Institutions

The uncertainty of disease risk faced by individuals manifests in that the timing and severity of disease, disability, or discomfort are unknown. Basic medical insurance can reduce medical costs through a mutual aid and risk-sharing mechanism jointly funded by the state, society, and individuals, and has a certain constraining effect on residents' medical behavior. According to the official website of Guangdong Provincial Medical Security Administration, by the end of 2021, the number of basic medical insurance participants in the province reached 110 million [34], with the vast majority of residents participating in basic medical insurance. With the development of social economy and the deepening of medical insurance reform, residents' demand for health services has been further released. The study found that the number of urban-rural resident basic medical insurance participants and the number of urban employee medical insurance participants ranked second and fifth respectively in correlation strength with patient visits in primary healthcare institutions, indicating that medical insurance enrollment numbers have a significant impact on patient visits in primary healthcare institutions. However, previous studies have shown that differentiated reimbursement ratios have a certain impact on residents' primary care behavior. When the reimbursement ratio gap between different levels of medical institutions is 10-15% [35], the leverage effect of medical insurance payment on residents' choice of medical institutions is weak. Currently, the reimbursement ratio of community hospitals is only five percentage points higher than that of tertiary medical institutions [36]. The small gap in medical insurance payment ratios between various levels of medical institutions makes it difficult to effectively incentivize residents economically to seek primary care. Due to risk aversion preferences, residents are more likely to choose higher-level medical institutions, which may be one of the main reasons for the declining proportion of patient visits in primary healthcare institutions.

3.4 Health Resource Allocation Has a Certain Impact on Patient Visits in Primary Healthcare Institutions

Studies have shown that health resource elements such as facilities and personnel allocation have a positive impact on the service output of primary healthcare institutions [37]. In recent years, Guangdong has successively formulated and implemented policies such as the "Guangdong Province Urban Health Support for Primary Health Implementation Plan (2013 Edition)" and the "Guangdong Province Primary Health Talent Team Construction Three-Year Action Plan (2018-2020)" , supporting the construction of new village clinics and township health centers in rural and remote areas, and strengthening the standardized construction of primary healthcare institutions. The improvement of health resource allocation in primary healthcare institutions has brought about an increase in patient visits to some extent. The study found that bed allocation in primary healthcare institutions (r=0.893) and the number of primary health-

care institutions (r=0.886) both have a certain correlation with patient visits in primary healthcare institutions, ranking third and fourth respectively in correlation strength, indicating that optimizing primary health resource allocation has a certain promoting effect on increasing primary care visits. However, due to reasons such as low technical level in some primary healthcare institutions, slow equipment updating, incomplete drug catalogs, poor waiting environments, weak service capacity, and insufficient technological innovation [38-39], the service capacity of primary healthcare institutions is uneven and cannot well meet the increasingly diversified medical needs of residents, which may be an important reason for patient loss in primary healthcare institutions.

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4. Recommendations

4.1 Taking Multiple Measures to Consolidate the Foundation of the Hierarchical Medical System

Through SMS push, outdoor advertising, and other methods, strengthen publicity to improve residents' awareness and support rate of hierarchical medical treatment. Improve the management measures for multi-site practice of physicians, encourage doctors from large hospitals within medical alliances to open expert clinics in primary healthcare institutions, and improve the accessibility of high-quality medical services in primary healthcare institutions. Accelerate the reform of income distribution in primary care, cancel the total wage limit, improve the enthusiasm of primary healthcare personnel to provide services, continue to implement special plans for improving primary service capacity, organize on-the-job personnel to regularly participate in business learning in higher-level medical institutions, encourage experts to teach diagnostic and treatment experience in the form of "master-apprentice", and improve the diagnostic and treatment level of primary care. Starting with specific diseases, explore the establishment of unified referral standards and two-way referral procedures to enhance the standardization of referral behavior by medical personnel.

4.2 Providing Convenient Primary Health Services in the Context of Population Aging

In response to the health challenges brought by population aging, the government should strengthen the detection, analysis, evaluation, and intervention of residents' health risk factors, strengthen the prevention and control of key diseases, strengthen follow-up management services for the elderly and chronic disease patients in the jurisdiction, and improve the early diagnosis rate and standardized treatment level of common chronic diseases among the elderly such as hypertension, diabetes, and osteoporosis. It is recommended that primary healthcare institutions dynamically adjust the number of appointment slots according to the pattern of patient visits, open "one-stop" comprehensive service windows to reduce repeated queuing by patients, and consolidate the advan-

tage of proximity of primary healthcare institutions by providing convenient services such as traditional Chinese medicine decoction, case copying, medication consultation, drug delivery, health policy consultation, dietary guidance, and wheelchair rental, guiding residents to gradually form the habit of "first contact at primary care" .

4.3 Steadily Expanding Medical Insurance Coverage and Widening the Payment Gap Between Different Levels of Medical Institutions

For residents not participating in basic medical insurance, continue to expand the coverage of basic medical insurance to ensure residents can enjoy basic medical services. Establish incentive mechanisms for medical institutions at all levels in the same direction to avoid higher-level medical institutions competing with primary healthcare institutions for patients. Increase the medical insurance payment ratio for difficult and severe disease groups in tertiary hospitals, reduce the reimbursement ratio for ordinary outpatient and ordinary inpatient services in higher-level medical institutions, and suggest expanding the gap in medical insurance payment ratios between primary healthcare institutions and tertiary medical institutions to about 20% [24]. Through the leverage effect of medical insurance payment, adjust residents' medical treatment flow and further consolidate the foundation for the first contact system at primary care.

4.4 Enhancing the Service Capacity of Primary Healthcare Institutions from Multiple Perspectives

Carry out standardized construction of primary healthcare institutions, improve the diagnosis and treatment environment, update facilities and equipment in a timely manner, increase self-service facilities, and suggest accelerating the application of big data and cloud computing at the primary level to drive service output quantity through service efficiency improvement. Increase the proportion of performance wages and post allowance subsidies for primary healthcare personnel, encourage on-the-job further education and competitive employment, increase the number of primary-level establishment positions, and recommend that health professionals who have obtained intermediate professional titles and have worked continuously in primary healthcare institutions for a certain number of years be directly recognized as having senior professional titles to solve the development bottleneck of scarce health talent at the primary level. Accelerate the alignment of drug catalogs between primary healthcare institutions and higher-level medical institutions to meet the medication needs of special groups such as children, chronic disease patients, and the elderly in primary healthcare institutions.

In summary, this study explores the main influencing factors of patient visits in primary healthcare institutions from a macro perspective using grey relational analysis, providing a reference basis for relevant government departments to take targeted measures to deepen the construction of the hierarchical medical system. The study has certain innovation in the selection of research perspective.

However, there are still the following limitations: First, the influencing factors of patient visits in primary healthcare institutions are complex and diverse, and due to the unclear boundaries of grey systems, some factors have not been included in this study. Second, correlation analysis is essentially a quantitative comparative analysis of the development trends of various sequence data in a dynamic process, and cannot conduct statistical significance tests on influencing factors.

Author Contributions: XU Bixia and YAO Weiguang were responsible for conceptualization and design, and feasibility analysis of the study. XU Bixia was responsible for data collection and collation, statistical processing, results analysis and interpretation, and manuscript writing. XU Bixia and YAO Weiguang were responsible for manuscript revision, quality control, and review. YAO Weiguang had overall responsibility for the article and provided supervision.

Conflicts of Interest: None.

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Note: Figure translations are in progress. See original paper for figures.