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 While China' s tiered healthcare system has achieved certain progress, the development of primary healthcare institutions remains relatively slow. Objective To analyze the trends in patient visits to primary healthcare institutions in Guangdong Province from 2013 to 2020 and their influencing factors, thereby providing a reference for the government to deepen the development of the tiered healthcare system. Methods Influencing factors were selected from four dimensions: sociodemographic structure, economic factors, health resource allocation, and medical insurance enrollment status. The grey relational analysis method was employed to evaluate the strength of association between each influencing factor and patient visits to primary healthcare institutions. Results In 2020, due to the special impact of the COVID-19 pandemic, patient visits to both hospitals and primary healthcare institutions decreased significantly. The proportion of primary healthcare institutions in total patient visits of medical institutions declined from 50.7% in 2013 to 48.1% in 2020. Grey relational analysis results showed that permanent population (r = 0.913) and population aged 65 and above (r = 0.913) had the strongest association with patient visits to primary healthcare institutions, followed by the number of enrollees 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 enrollees in urban employee medical insurance (r = 0.872). Conclusion Currently, many patients still flock to hospitals for medical care, and the primary care gatekeeping system needs to be strengthened. It is recommended that, in light of the social context of population aging, residents' need for accessing medical care nearby be met through three approaches: enriching the content of primary healthcare services, widening the gap in medical insurance reimbursement

between different levels of medical institutions, and enhancing the service capacity of primary healthcare institutions.

Full Text

Changes in Patient Visits to Primary Healthcare Institutions in Guangdong Province and Associated Determinants: A Grey Correlation Analysis

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Abstract

Background: While China' s hierarchical diagnosis and treatment system has achieved certain progress, the development of primary healthcare institutions remains relatively slow.

Objective: To analyze changes in patient visits to primary healthcare institutions in Guangdong Province from 2013 to 2020 and identify associated determinants, providing an evidence base for government to deepen the hierarchical diagnosis and treatment system.

Methods: Influencing factors were selected across four dimensions: sociodemographic structure, economic factors, health resource allocation, and medical insurance enrollment. Grey correlation analysis was employed to evaluate the strength of association between each factor and patient visits to primary healthcare institutions.

Results: The COVID-19 pandemic in 2020 caused significant declines in patient visits to both hospitals and primary healthcare institutions. The proportion of total patient visits occurring in primary healthcare settings decreased from 50.7% in 2013 to 48.1% in 2020. Grey correlation analysis revealed that

permanent resident population (r = 0.913) and population aged over 65 years (r = 0.913) showed the strongest association with primary healthcare visits, followed by urban and rural residents covered by basic medical insurance (r = 0.899), number of beds in primary healthcare institutions (r = 0.893), number of primary healthcare institutions (r = 0.886), and urban employees covered by basic medical insurance (r = 0.872).

Conclusion: Currently, many patients still prefer hospital care, indicating the need to strengthen the primary care first-visit system. Recommendations include: enriching primary healthcare service content, widening reimbursement gaps across different medical institution levels, and enhancing service capacity of primary healthcare institutions, particularly in the context of population aging.

Keywords: Hierarchical diagnosis and treatment; Primary healthcare institutions; Patient visits; Grey correlation analysis

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Introduction

Establishing a hierarchical diagnosis and treatment system represents a crucial initiative for rationally allocating medical resources and forming a scientific, orderly healthcare-seeking pattern in China, and constitutes an important component of the new round of healthcare system reform. While this hierarchical system has initially taken shape, its promotional effect on primary healthcare institution development remains generally limited [1], with these institutions continuing to develop at a relatively slow pace. In Guangdong Province, for example, primary healthcare institutions recorded 349.124 million patient visits in 2020, accounting for only 48.1% of total medical institution visits—far below the target of $ \$65\% $ [2, 3]. The *Guangdong Province Health Development "14th Five-Year" Plan* explicitly states that during the 14th Five-Year period, support for primary healthcare institution development must continue and the hierarchical diagnosis and treatment system must be accelerated [4].

Current research on factors influencing hierarchical diagnosis and treatment predominantly examines micro-level perspectives such as travel distance, with less attention to macro-level factors like economic development and sociodemographic structure [5], despite their broad influence on residents' healthcare-seeking patterns. Therefore, this study describes the current status of patient visits to primary healthcare institutions in Guangdong Province and employs grey correlation analysis to explore the main determinants of changes in primary care visits, providing a reference basis for government departments to deepen hierarchical diagnosis and treatment system construction.

1. Methods

1.1 Data Sources Data on patient visits were obtained from the *Guangdong Health Statistics Yearbook* (2013-2015), *Guangdong Health and Family Planning Statistics Yearbook* (2016-2017), and *Guangdong Health Statistics Yearbook* (2018-2020). Information on per capita disposable income and population data came from the *Guangdong Statistical Yearbook 2021*. Data on fiscal subsidies to primary healthcare institutions and medical insurance enrollment were sourced from the *China Health and Family Planning Statistics Yearbook* (2015-2017) and *China Health Statistics Yearbook* (2018-2021). "Primary healthcare institutions" in this study include community health service centers (stations), township hospitals, clinics, outpatient departments, health posts, infirmaries, and village clinics.

1.2 Theoretical Framework and Analytical Methods

1.2.1 Theoretical Basis: Grey System Theory Control theory uses white, grey, and black to describe the degree of information clarity—white represents completely clear information, black indicates unknown information, and grey signifies information clarity between these extremes [6]. Grey system theory, first established by Professor Deng Julong [7], studies "small-sample, poor-information, uncertain" systems by mining and analyzing known information to explore evolution patterns and predict development trends [6]. Patient volume at primary healthcare institutions is influenced by both subjective and objective factors including residents' healthcare-seeking behavior, health resource allocation, sociodemographic characteristics, and medical insurance enrollment, forming a typical grey system where some information is known and some unknown. Therefore, grey system theory is appropriate for analyzing factors influencing primary healthcare patient volume.

1.2.2 Grey Correlation Analysis Method Grey correlation analysis compares the geometric similarity of time series curves to assess correlation strength—the closer the geometric shape of a comparison sequence to the reference sequence, the stronger their association [8, 9]. Unlike traditional linear regression, which requires large sample sizes and specific distributions, grey correlation analysis is not constrained by these conditions. Given data availability, this method is suitable for analyzing factors influencing primary healthcare patient volume.

The analysis proceeds as follows:
(1) Determine the reference sequence X_0 and comparison sequences X (i = 1, 2, ···, m);
(2) Apply initial value or mean value methods for dimensionless processing of raw data to obtain X'$_0$ and X' (i = 1, 2, ···, m);
(3) Calculate absolute differences Δ between X'$_0$ and X' : Δ (k) = |X'$_0$(k) - X' (k)|, where i = 1, 2, ···, m and k = 1, 2, ···, n;
(4) Identify the minimum (Min) and maximum (Max) values among all Δ (k),

set the resolution coefficient to 0.5, and compute correlation coefficients (with i and k values as above);
(5) Calculate correlation degrees (with i and k values as above).

1.2.3 Selection of Potential Influencing Factors Drawing on the four-part model developed by the RAND Corporation based on the "one process, four components" theoretical hypothesis of healthcare utilization [10], and referencing research by Shen Xiaoyan [11], Rao Keqin [12], Shi Long [5], and others, this study selected influencing factors from four dimensions while considering data availability. Using primary healthcare institution patient visits as the reference sequence, factors were selected from:
- **Resource allocation**: number of primary healthcare institutions, beds, health technicians, licensed (assistant) physicians, and registered nurses;
- **Sociodemographic characteristics**: permanent resident population, proportion of population aged over 65, proportion aged 0-14;
- **Economic factors**: per capita disposable income of urban and rural residents, fiscal subsidy income of primary healthcare institutions;
- **Medical insurance enrollment**: number of urban employee basic medical insurance enrollees and urban resident basic medical insurance enrollees.

2. Results

2.1 Proportion of Patient Visits to Primary Healthcare Institutions From 2013 to 2019, hospital patient visits in Guangdong Province grew from 334.592 million to 401.317 million, with an average annual growth rate of 3.08%. During the same period, primary healthcare institution visits grew at an average annual rate of 2.10%, reaching 437.317 million visits in 2019. Overall, total medical institution visits in Guangdong showed stable growth, increasing to 891.046 million in 2019 with an average annual growth rate of 2.69%. The COVID-19 pandemic in 2020 caused significant declines in visits to both hospitals and primary healthcare institutions. However, the proportion of total visits occurring in primary healthcare settings showed a slow downward trend, decreasing from 50.7% in 2013 to 48.1% in 2020, while the hospital proportion gradually increased. See Table 1 .

2.2 Influencing Factors on Primary Healthcare Patient Visits This study used primary healthcare institution patient visits (X_0, in 10,000 visits) as the reference sequence, with comparison sequences including: number of primary healthcare institutions (X_1), beds (X_2), health technicians (X_3), licensed (assistant) physicians (X_4), registered nurses (X_5), permanent resident population (X_6), population aged over 65 (X_7), population aged 0-14 (X_8), per capita disposable income of urban residents (X_9), per capita disposable income of rural residents (X_{10}), fiscal subsidy income (X_{11}, in 100 million yuan), urban employee medical insurance enrollees (X_{12}), and urban resident basic medical insurance enrollees (X_{13}). See Table 2 .

2.3 Dimensionless Processing Results The mean value method was applied for dimensionless processing of raw data from Table 1, with results shown in Table 3 . After dimensionless processing, absolute differences between comparison sequences and the reference sequence were calculated for each year. The minimum absolute difference was 0.001 and the maximum was 0.797. See Table 4 .

2.4 Grey Correlation Analysis Results Correlation degrees between each comparison sequence and the reference sequence were calculated and ranked. Higher ranking indicates stronger association with primary healthcare patient visits. The ranking was: $r_6 = r_7 > r_{13} > r_2 > r_1 > r_{12} > r_8 > r_4 > r_9 > r_3 > r_{10} > r_5 > r_{11}$. The main influencing factors were permanent resident population (X_6), population aged over 65 (X_7), urban and rural resident basic medical insurance enrollees (X_{13}), number of beds (X_2), number of primary healthcare institutions (X_1), and urban employee medical insurance enrollees (X_{12}). See Table 5 .

3. Discussion

3.1 Declining Proportion of Primary Healthcare Visits in Guangdong The proportion of total patient visits occurring in primary healthcare institutions decreased from 50.7% in 2013 to 48.1% in 2020, remaining distant from the 65% policy target [2]. This suggests the distribution of patient volume across medical institutions remains suboptimal, with services not adequately shifting to primary care. Current health resource allocation efficiency in Guangdong' s primary healthcare institutions has not reached optimal input-output status—most township hospitals receive adequate or even redundant funding while producing relatively few outpatient and inpatient services [13]. Previous research indicates that economic development indirectly suppresses the proportion of primary healthcare visits through improved transportation accessibility and increased per capita disposable income [5]. As infrastructure development enhances transportation convenience and rising incomes reduce financial barriers to care, residents increasingly choose higher-level institutions, especially given the lack of strict gatekeeping requirements. The concentration of high-quality resources in public hospitals, driven by administrative systems, further intensifies this "siphoning effect" [14]. Additionally, increased basic public health service workloads have squeezed time for medical services, reducing primary healthcare workers' motivation [15]. Furthermore, Guangdong has not established unified two-way referral standards and procedures, leaving referral decisions largely to individual judgment and patient preference, creating arbitrary and subjective referral patterns that may inappropriately direct patients who could be treated at primary level to higher-level institutions [16].

3.2 Strong Association Between Primary Healthcare Visits and Sociodemographic Structure Permanent resident population ($r = 0.913$) and

population aged over 65 (r = 0.913) showed the strongest association with primary healthcare visits, with highly similar development trends and rates, indicating that sociodemographic changes constitute the main driver of primary healthcare patient volume fluctuations. Internationally, a society is considered aging when over 10% of its population is aged 60+ or over 7% is aged 65+. Guangdong data show the proportion aged 65+ increased from 7% in 2012 to 8.58% in 2020 [17]. Deepening population aging highlights health issues including chronic diseases, disability, and depression, increasing healthcare demand. However, due to information asymmetry, patients primarily consider medical technology level, cost burden, and transportation convenience when choosing institutions [18]. Large-sample empirical studies show Chinese elderly prefer large public institutions, tending to seek care at public, non-primary facilities [19], particularly for hospitalization. This preference for higher-level care likely contributes significantly to the declining proportion of primary healthcare visits.

3.3 Medical Insurance Enrollment Growth Promotes Primary Healthcare Visits Disease risk uncertainty manifests in unknown timing and severity of illness, injury, or discomfort. Basic medical insurance establishes a risk-sharing mechanism through joint funding by government, society, and individuals, reducing healthcare costs and influencing healthcare-seeking behavior. By the end of 2021, Guangdong' s basic medical insurance covered 110 million residents [20], with universal coverage largely achieved. Socioeconomic development and deepening insurance reforms have further unleashed healthcare demand. Our analysis shows urban-rural resident basic medical insurance enrollees and urban employee insurance enrollees ranked second and fifth in association strength, respectively, indicating substantial influence. However, research shows that when reimbursement gaps between institution levels are only 10-15%, insurance leverage has weak constraint effects on institution choice [21]. Currently, community hospitals' reimbursement rates are only five percentage points higher than tertiary hospitals [22], insufficient to provide effective economic incentives for primary care utilization. Risk-averse residents thus prefer higher-level institutions, contributing to declining primary healthcare visit proportions.

3.4 Health Resource Allocation Influences Primary Healthcare Patient Volume Studies demonstrate that health resources including facilities, equipment, and personnel positively influence primary healthcare service output [23]. Guangdong has implemented policies such as the *Guangdong Urban Support for Primary Healthcare Implementation Plan (2013)* and *Three-Year Action Plan for Primary Healthcare Talent Development (2018-2020)*, supporting new village clinics and township hospitals in remote areas and strengthening standardized construction. Improved resource allocation has increased patient volume to some extent. Our findings show number of beds (r = 0.893) and number of institutions (r = 0.886) ranked third and fourth in association strength, suggesting resource optimization promotes primary care utilization. However, uneven service capacity across institutions—due to low technical levels, outdated

equipment, incomplete drug formularies, poor waiting environments, weak service capacity, and insufficient technological innovation [24, 25]—fails to meet residents' growing and diversifying healthcare needs, likely causing patient loss.

4. Recommendations

4.1 Strengthen Hierarchical Diagnosis and Treatment System Foundation Through Multiple Measures Enhance public awareness and support for hierarchical diagnosis and treatment through SMS campaigns and outdoor advertising. Improve multi-site practice regulations to encourage hospital doctors to establish specialist clinics in primary healthcare institutions, increasing accessibility to high-quality services. Accelerate primary-level income distribution reforms by removing salary caps to motivate healthcare workers. Continue implementing capacity-building programs, organizing regular training at higher-level hospitals and encouraging mentorship programs to improve clinical skills. Establish unified referral standards and two-way referral procedures for specific diseases to standardize referral behaviors.

4.2 Provide Convenient Primary Healthcare Services in Response to Population Aging Addressing aging-related health challenges, governments should strengthen monitoring, analysis, evaluation, and intervention of health risk factors, enhance prevention and control of key diseases, and improve follow-up management for elderly and chronic disease patients. Primary healthcare institutions should dynamically adjust appointment slots based on visit patterns, establish "one-stop" service windows to reduce repeated queuing, and consolidate proximity advantages by offering convenient services including traditional Chinese medicine preparation, medical record copying, medication consultation, drug delivery, health policy consultation, dietary guidance, and wheelchair rental to gradually cultivate residents' primary care first-visit habits.

4.3 Expand Insurance Coverage and Widen Reimbursement Gaps Across Institution Levels Continue expanding basic medical insurance coverage to ensure all residents access essential services. Establish aligned incentive mechanisms across institution levels to prevent competition for patients. Increase reimbursement rates for complex and severe cases at tertiary hospitals while reducing rates for general outpatient and inpatient services. Expand the reimbursement gap between primary and tertiary institutions to approximately 20% [22], using insurance payment leverage to redirect patient flow and strengthen the primary care first-visit system.

4.4 Enhance Primary Healthcare Institution Capacity Through Comprehensive Measures Implement standardized construction to improve clinical environments, update facilities and equipment, and add self-service facilities. Accelerate application of big data and cloud computing at primary level to boost service efficiency and output. Increase performance-based pay proportions and

position subsidies for primary healthcare staff, encourage continuing education and competitive employment, and expand staffing quotas. Recommend direct recognition of deputy senior professional titles for mid-level professionals who have worked continuously in primary institutions for specified periods to address talent shortages. Accelerate alignment of drug formularies with higher-level hospitals to meet medication needs of children, chronic disease patients, and elderly populations.

5. Innovation and Limitations

This study innovatively examines primary healthcare patient volume from a macro perspective using grey correlation analysis to identify key influencing factors, providing targeted evidence for policy-making. However, several limitations exist: First, numerous factors influence primary healthcare visits, and due to unclear grey system boundaries, some factors were not included. Second, correlation analysis quantitatively compares development trends across sequences but cannot determine statistical significance.

Author Contributions: XU Bixia and YAO Weiguang conceptualized the study and designed the methodology. XU Bixia collected and organized data, performed statistical analysis, interpreted results, and drafted the manuscript. XU Bixia and YAO Weiguang revised the manuscript. YAO Weiguang supervised quality control and is responsible for the overall content. All authors approved the final manuscript.

Conflict of Interest: The authors declare no conflict of interest.

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