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The Impact of Uneven Allocation of Health Resources on Residents in Different Regions: An Empirical Study of Guangdong Province

LI Yugang

Doctor of Management

Supervisor:
PhD Álvaro Rosa, Associate Professor,
ISCTE University Institute of Lisbon

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BUSINESS
SCHOOL

Marketing, Operations and General Management Department

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Abstract

A equitable distribution of medical resources serves as a critical lever for promoting population health and sustainable development, and this issue has turned into a fundamental consensus among decision-makers and researchers. However, structural barriers—including regional economic disparities, fiscal decentralization systems, and the concentration of talent in urban centers—continue to impede the equitable allocation of high-quality medical resources, presenting significant challenges to achieving equity in the access to health.

This study employed a mixed-methods approach, integrating expert consultation, questionnaire surveys, longitudinal panel data (2011-2020), Theil index decomposition, and in-depth interviews to assess the current state of medical resource allocation and examine the impact of distributional inequities on regional health disparities and overall population health outcomes. The results revealed that the Pearl River Delta region received significantly higher investment in medical resources and exhibited greater resource concentration compared to the eastern, western, and northern regions of Guangdong Province. Residents in remote areas demonstrated significantly higher prevalence in chronic diseases and exhibited consequently higher mortality rates. These adverse health effects of resource disparities were further exacerbated by population aging and low medical insurance coverage rates.

This study recommends targeted public policy measures—such as fiscal transfers, community-level infrastructure investments, and talent incentive programs—to foster more equitable and resilient health systems.

Keywords: Medical resource allocation; Regional health disparities; Health equity; Fiscal and talent policies

JEL: I11; I18

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Resumo

Uma distribuição equitativa dos recursos de saúde constitui um elemento fundamental para a promoção da saúde da população e para um desenvolvimento sustentável, sendo este facto amplamente reconhecido por decisores políticos e investigadores. No entanto, barreiras estruturais — incluindo disparidades económicas regionais, sistemas de descentralização fiscal e a concentração de profissionais de saúde nos centros urbanos — continuam a dificultar a distribuição equilibrada de recursos de saúde de qualidade, colocando sérios desafios à concretização da equidade no acesso aos cuidados de saúde.

Este estudo adota uma abordagem de métodos mistos, integrando consulta a peritos, inquérito por questionário, dados de painel longitudinal (2011–2020), decomposição do índice de Theil e entrevistas em profundidade, com o objetivo de avaliar a situação atual da alocação de recursos de saúde na província de Guangdong, China, bem como examinar o impacto das desigualdades distributivas nas disparidades regionais em saúde e nos resultados em saúde da população. Os resultados mostram que a região do Delta do Rio das Pérolas recebeu um investimento significativamente superior em recursos de saúde e apresenta uma maior concentração desses recursos quando comparada com as regiões leste, oeste e norte da província de Guangdong. Os residentes das zonas mais remotas apresentam maior prevalência de doenças crónicas e, consequentemente, taxas de mortalidade mais elevadas. Estes efeitos adversos são ainda agravados pelo envelhecimento demográfico e pela baixa cobertura do seguro de saúde.

Com base nestes resultados, o estudo propõe medidas de política pública direcionadas, nomeadamente transferências fiscais, investimento em infraestruturas de saúde ao nível comunitário e mecanismos de incentivo e retenção de profissionais, com vista à promoção de um sistema de saúde mais equitativo, resiliente e sustentável.

Palavras-chave: Distribuição de recursos médicos; Desigualdades regionais de saúde; Equidade em saúde; Políticas fiscais e de recursos humanos

JEL: I11; I18

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摘 要

医疗资源的公平配置是促进全民健康与可持续发展的关键环节，已成为政策制定者与学术界的广泛共识。然而，地区经济差距、财政分权体制以及医疗人才向城市集中的结构性问题，仍然制约着高质量医疗资源的合理流动与均衡分布，对实现健康公平构成了重大挑战。

本研究采用混合研究方法，综合运用专家咨询、问卷调查、2011—2020 年面板数据分析、泰尔指数分解以及深度访谈等手段，系统评估广东省医疗资源配置的现状，并探讨资源分配不均对区域健康差异及人口健康水平的影响。研究结果显示，珠三角地区的医疗资源投入和集中度显著高于粤东、粤西和粤北地区；偏远地区居民慢性病患病率较高，死亡率亦明显上升。资源不均带来的健康不利影响还因人口老龄化和医疗保险覆盖率偏低而进一步加剧。

基于此，研究建议通过财政转移支付、基层医疗基础设施建设和医疗人才激励机制等有针对性的公共政策措施，推动实现医疗资源的均衡配置，构建更加公平、可持续且具备韧性的卫生体系。

关键词：医疗资源配置；区域健康差异；健康公平；财政与人才政策

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Chapter 1: Introduction

1.1 General setting

Health is the cornerstone of personal development and social progress, and the improvement of public health is directly related to social equity and sustainable economic development. Globally, the imbalance in healthcare resource allocation has been exacerbated by various factors including urbanization, demographic shifts, and economic inequality. The increasing urban-rural divide and disparities in regional healthcare access have led to unequal health outcomes across different areas. For example, in developing countries, even with national healthcare systems in place, healthcare workers tend to be more concentrated in urban centers, leaving rural areas under-served. This uneven distribution often forces rural residents to travel long distances to access even basic health services, which not only delays treatment but also increases their economic burden. Such delays can result in the progression of otherwise manageable diseases, thereby worsening health outcomes and perpetuating cycles of poverty and ill health within these communities. This trend is also evident in developed nations where even universal healthcare systems face challenges in addressing inequalities. The expansion of healthcare infrastructure often fails to keep pace with rapid population growth in urban areas, leading to overcrowded hospitals and long wait times. On the other hand, rural areas, especially in economically underdeveloped regions, face the challenge of retaining healthcare professionals, which exacerbates the issue of limited access to care. Realizing universal health coverage and guaranteeing citizens' right to health is a major responsibility of all governments. The allocation of healthcare resources, as a key link in realizing this goal, not only reflects the level of national healthcare services, but also exerts a profound impact on people's health rights and interests and social stability. Rationality and equity in the allocation of healthcare resources directly affect the healthcare resource allocation efficiency and healthcare accessibility of the residents, which in turn determines the direction of the medical reform. Patterns of allocation thus influence institutional priority-setting, the organization of service networks, and the balance between cost control and fairness in access. Rational allocation emphasizes the efficiency of resource utilization, while equity ensures that services cover all residents. In practice, aligning efficiency with fairness requires calibrating resource deployment so that

marginal gains in utilization do not come at the expense of population coverage, particularly for residents in remote and rural communities. At the same time, the balance between efficiency and equity is not static but evolves along with demographic transitions, technological advancements, and changing disease burdens. This requires continuous recalibration of allocation mechanisms to ensure that incremental gains in medical technology and institutional capacity are shared broadly rather than reinforcing existing disparities. Specifically, the rational distribution of healthcare resources determines whether residents can obtain timely, affordable, and high-quality medical services, directly influencing public health outcomes as well as broader indicators of social development. For instance, when primary healthcare services are inadequately allocated, common conditions such as hypertension or diabetes may go untreated at an early stage, eventually requiring more complex and costly interventions at tertiary hospitals. This inefficiency highlights how the quality and timeliness of care are closely tied to the fairness of resource distribution. When resource allocation fails to keep pace with demographic and epidemiological transitions, it often leads to regional healthcare disparities that manifest in uneven service accessibility, widening health gaps between urban and rural populations, and ultimately undermining the overall efficiency of the healthcare system. Healthcare resources can be defined in a broad sense and narrow sense. Clarifying this distinction helps to avoid conceptual ambiguity and to align measurement with the specific policy levers under consideration. Healthcare resources in the broad sense cover all social resources needed to carry out health care activities, including human, material and financial resources. From this perspective, the effectiveness of healthcare delivery depends on the coordinated input of personnel, equipment, and financing, rather than on any single element in isolation. In practice, neglecting the interdependence of these elements often leads to inefficiencies, where investments in equipment without adequate personnel training, or financial input without sustainable infrastructure, fail to produce the expected health gains. Thus, effective allocation requires treating healthcare resources as an integrated system rather than fragmented components. Health resources in the narrow sense refer specifically to the resources provided by society for the healthcare sector, mainly including medical equipment, medicines, and healthcare professionals.

Since the implementation of the reform and opening up policy, China has experienced rapid economic development, and the total quantity and quality of healthcare resources have also improved significantly. Yet the pace of improvement has varied across locations and levels of care, with notable disparities in the expansion of facilities, equipment, and personnel. However, the problem of imbalance in the input and allocation of healthcare resources remains prominent,

as there are significant differences in resource allocation between regions and between urban and rural areas, with high-quality resources being overly concentrated in developed areas. These differences are reflected in uneven service capacity, longer travel and waiting times for some residents, and marked contrasts in the continuity of care between metropolitan centers and peripheral areas. These disparities also manifest in subtle but important ways, such as differences in patient – doctor communication, follow-up care, and the availability of preventive health programs. Residents in peripheral regions often face not only quantitative shortages but also qualitative gaps in the comprehensiveness and reliability of services, which cumulatively erode trust in the healthcare system. The main contradiction in China has been transformed into “the contradiction between the people’s growing needs for a better life and unbalanced and inadequate development”. In the field of healthcare, this contradiction is reflected in the gap between “the people’s ever-increasing demand for medical and health care services and the unbalanced resource supply and insufficient development”. At the service delivery level, this tension appears in the concentration of patient flows in higher-level institutions and the insufficient ability of some basic facilities to meet routine needs, which further amplifies regional and urban–rural divides. Equitable and rational allocation of healthcare resources will help to improve the accessibility of basic healthcare services and promote the health of the entire population. Advancing toward this goal contributes to the equalization of basic public services and reinforces the legitimacy of ongoing healthcare reforms.

In 2015, China formulated its first plan for the healthcare service system at the national level, namely, *Outline of the National Healthcare Service System Plan (2015-2020)*, aiming to develop the healthcare service system in an appropriate and orderly manner, adjust the structure, achieve systematic integration, promote balanced resource allocation, and promote the further optimization of the allocation of medical and healthcare resources in China State Council of the People's Republic of China (2015). Since the Healthy China Strategy was put forward in 2018, the supply capacity and allocation level of healthcare services and resources have faced larger tests. In 2019, *Opinions of the State Council on the Implementation of the Healthy China Initiative* explicitly pointed out that by 2030, the level of health literacy of the whole Chinese population would be significantly improved, and health equity would be basically realized (State Council of the People's Republic of China, 2019). The Fifth Plenary Session of the Nineteenth Central Committee of the Communist Party of China also put forward major economic and social goals such as realization of a new level of people’s livelihood and well-being and significant improvement of the equalization of basic public services during the 14th

Five-Year Plan. However, the outbreak of COVID-19 has exposed the structural shortcomings of China's healthcare system. The dual pressures of infectious disease prevention and control and chronic disease management have highlighted the constraints of uneven resource distribution on public health emergency response capacity. The uneven geographical spread of intensive care units and the shortage of infectious disease specialists in less-developed regions became particularly evident during the early stages of the pandemic, where patients in smaller cities and rural areas had limited access to life-saving equipment such as ventilators. These shortages placed disproportionate stress on regional health systems, revealing the fragility of existing allocation mechanisms under crisis conditions. Currently, healthcare resources in China are still facing problems such as insufficient total amount, relatively low quality, and imbalanced distribution, and differences in service accessibility between regions have further exacerbated health inequality. These disparities are particularly evident in areas with limited healthcare infrastructure and insufficiently trained medical personnel, where even basic public health interventions such as routine vaccination, maternal and child health services, and chronic disease management may be inadequately delivered. In contrast, economically developed regions often possess advanced medical technologies, specialized hospitals, and a high concentration of healthcare professionals, enabling them to provide comprehensive services across the entire spectrum of care. This structural imbalance not only affects immediate healthcare delivery but also perpetuates long-term health inequities by restricting opportunities for preventive care and early disease detection in less developed areas. Moreover, the challenges are compounded by disparities in health literacy, where residents in underdeveloped regions often lack adequate knowledge about disease prevention and treatment. This gap magnifies the consequences of limited healthcare availability, as even when services exist, they may not be fully utilized or accessed in a timely manner. Moreover, these disparities are not merely quantitative but also qualitative. For instance, while some regions may appear to have adequate numbers of healthcare institutions per capita, the actual service capacity—such as the availability of specialized departments, diagnostic equipment, or experienced healthcare professionals—remains significantly limited. This superficial equity masks underlying inadequacies, where residents may still face long waiting times, delayed diagnoses, or unnecessary referrals to higher-level hospitals. Furthermore, these inefficiencies place additional burdens on tertiary hospitals, which become overcrowded as patients bypass primary healthcare institutions due to concerns over service quality. As a result, healthcare costs escalate, medical resources are consumed disproportionately by a small number of large hospitals, and the hierarchical medical system fails to function as intended. The resulting cycle of uneven

utilization further amplifies the original disparities in healthcare resource allocation. Consequently, even in areas where statistical indicators suggest progress, the real-world experience of healthcare access continues to reflect deep-rooted inequalities, further reinforcing public dissatisfaction and undermining trust in the healthcare system. Differences in government investment, health insurance systems and economic development have led to a significant gap in the distribution of basic healthcare services between urban and rural areas and between different regions.

In the face of these problems, the Chinese government has adopted a series of policies to promote the healthcare service capacity of underdeveloped regions, proposed the construction of an integrated regional medical security system, and realized the equalization of basic healthcare services. Rational allocation of medical and healthcare resources, promotion of the equalization of public health services, and reduction of the differences in the level of medical and health services received by the residents of various regions are of great significance to the promotion of Healthy China. In practical terms, achieving this goal requires not only increasing the total amount of healthcare resources but also ensuring that these resources are effectively matched with local health demands. Provinces and municipalities with lower levels of economic development often face multiple constraints, such as limited fiscal capacity and insufficient medical education infrastructure, which make it difficult to retain qualified healthcare workers. Addressing these structural barriers is therefore essential for improving service coverage and ensuring that residents in all regions can equally benefit from the advances in healthcare provision. Practical measures in this direction often include strengthening the training pipeline of local healthcare professionals, improving incentives to retain medical staff in less developed areas, and fostering cooperation between large urban hospitals and rural health centers. While these efforts are ongoing, their effectiveness depends heavily on sustained investment and careful monitoring to prevent the recurrence of inequities over time. The equalization of healthcare resources reflects social justice and health equity, and is a prerequisite for achieving the goal of “health for all”. The construction of an integrated regional medical security system and the realization of relatively equalized basic medical and health services for all are the requirements for integrating urban and rural development and realizing balanced and coordinated regional development in China (Yuan, 2021), which is of great practical significance for the promotion of social fairness and stability, and the building of a moderately prosperous society in an all-round way. Moreover, the success of such reforms directly influences public perceptions of government performance and social justice, as healthcare is one of the most visible public services affecting people's daily lives. Only by narrowing the

disparities in healthcare resource allocation can China lay a solid foundation for sustainable economic growth, improve population health outcomes, and foster social cohesion in the long term. In recent years, healthcare resource allocation research has become a hot spot in the field of health care. Scholarly attention has increasingly focused on how to reconcile limited resource envelopes with rising expectations for accessible and high-quality services. In order to give full play to the social benefits of limited resources, this study reviews relevant studies from the following four aspects: 1) the theoretical basis of healthcare resource allocation; 2) the current situation of uneven regional allocation; 3) the reasons for uneven allocation; and 4) the impact on the health of residents. Together, these four dimensions provide a coherent framework in which normative criteria guide assessment, empirical description establishes the baseline, explanatory factors clarify the sources of disparity, and outcome-oriented analysis connects allocation patterns with population health. Through an in-depth analysis of regional disparities, this study proposes strategies for optimization of allocation, so as to provide a scientific basis for policy formulation. The synthesis emphasizes gradual, evidence-informed adjustments that strengthen basic service functions, improve coordination among institutions, and foster more balanced coverage across different types of areas.

1.2 Introduction of the dilemma/problem

At present, a large number of studies have been carried out on the status quo of medical resource allocation from different perspectives, which has improved and enriched the theory and practice of health resource allocation in China. These studies have provided valuable insights into the mechanisms behind healthcare resource distribution and have identified key challenges in achieving balanced healthcare provision across China. However, despite this growing body of research, there remains a lack of comprehensive frameworks that integrate both the quantitative and qualitative aspects of healthcare resource allocation, particularly with respect to local variations in healthcare access, quality, and utilization. However, there are still many problems and contradictions in China's health industry, such as excessive concentration of health resources in large urban hospitals, severe imbalance in the allocation of urban and rural health resources, and unequal access to basic public services (W. Li, 2015). These problems are compounded by the rapid urbanization that has accelerated the movement of healthcare services toward economically developed urban areas, leaving rural areas with fewer resources and less specialized care. This concentration of services in urban hubs also creates an unintended imbalance in patient flows, with large hospitals in metropolitan regions facing overwhelming

demand, while rural facilities remain underutilized. Such a pattern reduces the efficiency of the healthcare system as a whole, as patients bypass nearby primary care institutions in pursuit of perceived higher-quality services in cities. In the long run, this tendency further weakens the capacity of rural institutions, which struggle to attract both patients and qualified personnel, creating a self-reinforcing cycle of underdevelopment. As a result, healthcare disparities between urban and rural populations continue to widen, contributing to growing public dissatisfaction and a lack of trust in the fairness of the healthcare system. The imbalance not only affects access to high-level medical services but also limits the effectiveness of primary healthcare in rural regions, where preventative care and early diagnosis are often neglected due to insufficient facilities and healthcare professionals. The dual structure of urban and rural areas creates a gap between urban and rural areas in China in terms of not only economy, but also health care. This urban-rural divide has long been a challenge for China's healthcare system, where economic development in urban regions has far outpaced the growth in rural healthcare infrastructure. The disparity in healthcare resources between urban and rural areas is not only reflected in the number of healthcare institutions but also in the training, distribution, and retention of healthcare workers, which significantly hampers the ability of rural populations to access high-quality medical services. Moreover, the lack of structured professional development pathways in rural areas discourages young graduates from committing to long-term service outside urban centers. Even when rural areas succeed in recruiting new healthcare workers, high turnover rates often undermine continuity of care, leading to unstable doctor-patient relationships and diminished trust in local healthcare facilities. Consequently, rural residents may prefer to delay treatment until they are able to travel to larger hospitals, thereby missing opportunities for early intervention and prevention. Furthermore, the lack of financial incentives and career advancement opportunities for healthcare workers in rural areas exacerbates the problem, leading to a shortage of skilled personnel in these regions. Therefore, it is an important task in the reform of medical and health care system in China to solve the imbalance in the development of urban and rural health care undertakings, rationally allocate health resources, and realize the goal of basic health services for all (Y. Wang et al., 2019). Achieving this goal necessitates not only the redistribution of healthcare resources but also the establishment of policies that incentivize the development of healthcare infrastructure in underserved regions. The allocation of resources should be responsive to the unique needs of different populations, taking into account factors such as population density, disease burden, and economic conditions. Additionally, the implementation of telemedicine, mobile health services, and other technological innovations could help bridge the gap between urban and rural

areas by increasing healthcare access in remote regions where physical infrastructure is lacking.

Despite the progress made in existing studies, there are still some areas that have not been fully explored or studied in sufficient depth. For example, while substantial research has been conducted on the general allocation of healthcare resources, there is a noticeable gap in studies addressing the dynamic interaction between resource allocation, health outcomes, and policy changes over time. Much of the current research remains static, focusing on snapshot analyses of healthcare systems, without considering the long-term effects of resource allocation decisions or the adaptability of the system to future health challenges. Such static approaches risk overlooking gradual yet significant trends, such as the cumulative impact of population aging, the rising prevalence of chronic diseases, and the potential strain from recurrent public health emergencies. Without incorporating longitudinal perspectives, policy recommendations may fail to anticipate emerging pressures, resulting in short-term remedies rather than sustainable reforms. The integration of time-sensitive data could provide a more accurate picture of the evolving nature of healthcare resource needs and guide more responsive policy interventions. First, most of the existing empirical studies focus on the national level and lack in-depth analysis of specific provinces. This national-level focus often overlooks important regional variations in healthcare system performance, which can lead to policy recommendations that are not sufficiently tailored to the local context. Provinces, with their distinct demographic profiles, health challenges, and economic conditions, require individualized approaches to healthcare resource allocation. Without examining these regional differences, it is difficult to design policies that effectively address the unique needs of each area, thus hindering the successful implementation of healthcare reforms. For example, Zheng and Zhang (2012) used the stochastic frontier output distance function model and one-stage estimation to explore the technical efficiency of the healthcare system and its influencing factors in 31 provinces in the Chinese mainland. Xie and Fang (2013) used the Gini coefficient, DEA, and multiple linear regression equations to investigate the equity and efficiency of healthcare resource allocation in different provinces in China. However, most of these studies remain at the macro level, failing to present an in-depth analysis of the actual situation in specific provinces. As a result, the diversity of provincial healthcare landscapes—shaped by geography, fiscal capacity, and population health needs—remains insufficiently captured in existing analyses. Provinces with vast rural populations and limited fiscal revenues face challenges that are fundamentally different from those in coastal regions with dense urban settlements and advanced healthcare facilities. Without acknowledging these structural contrasts, the

formulation of policies risks being overly generalized and less effective in addressing local realities. To address this gap, future studies should delve deeper into provincial case studies that analyze the local healthcare context, examining how resource allocation decisions are made, the challenges faced by healthcare providers, and the resulting outcomes for patients. Such research would provide valuable insights into the effectiveness of current policies at the provincial level and offer actionable recommendations for improving healthcare delivery in regions that are most in need of reform. Second, existing studies mostly explore the rationality of allocation from the perspective of financial resources and lack an integrated analysis of human and material resources. While financial resources are undoubtedly a critical factor, a holistic approach to healthcare resource allocation must also consider the availability and distribution of human resources, such as healthcare professionals, and material resources, including medical equipment and infrastructure. A comprehensive analysis should also incorporate the efficiency with which these resources are utilized, as inefficient management can undermine the effectiveness of even the most well-funded healthcare systems. By integrating all dimensions of healthcare resources, more accurate and actionable recommendations can be made to improve both the efficiency and equity of the system. This single-dimension assessment is difficult to fully reflect the complexity of resource allocation. For instance, an analysis that only measures per capita financial input may suggest equity on the surface, while in reality, disparities in the availability of trained personnel or advanced equipment can lead to starkly different health outcomes. Such partial assessments therefore provide an incomplete foundation for decision-making, underscoring the need for multi-dimensional approaches that mirror the true complexity of healthcare delivery systems. The complexity of healthcare resource allocation requires a multi-dimensional analysis that takes into account various factors such as geographic location, population health needs, healthcare infrastructure, and workforce distribution. This complexity is further compounded by the changing nature of healthcare demands, driven by shifts in population demographics, emerging health threats, and advancements in medical technology. Thus, a more nuanced approach to resource allocation is essential, one that can adapt to the dynamic nature of the healthcare environment and provide solutions that are both sustainable and equitable in the long term. For example, although the study by Y. Zhu et al. (2023) provides a relatively comprehensive assessment of health resources in 31 provinces across China, it focuses on macro-analysis and fails to conduct detailed empirical studies of specific provinces, and the policy recommendations proposed are not targeted.

1.3 Purpose

To address the above issues, this study systematically explores the relationship between health resource allocation and residents' health status in Guangdong Province through multi-dimensional data collection and analysis, and proposes targeted policy recommendations. In particular, the study aims to provide a detailed and nuanced understanding of how the allocation of healthcare resources influences the health outcomes of different demographic groups across Guangdong Province. By systematically analyzing various health indicators and comparing them across regions, the study intends to uncover not only the direct impacts of resource allocation on health but also the underlying factors contributing to disparities in health outcomes. In doing so, the research also emphasizes the importance of tracing how these disparities evolve over time, thereby allowing for a clearer understanding of whether policy adjustments have effectively addressed existing imbalances or inadvertently deepened them. Such temporal insights are essential for evaluating the long-term sustainability of healthcare reforms and ensuring that short-term improvements translate into lasting progress. The research seeks to highlight specific areas where policy interventions could improve resource distribution and healthcare access. The research data comes from the following three empirical studies. These three distinct yet complementary empirical studies are designed to provide a comprehensive view of the current healthcare landscape in Guangdong Province. By incorporating both quantitative and qualitative data, the study aims to bridge the gap between objective statistical measures and subjective experiences, ensuring that the analysis reflects the complexity of healthcare resource allocation and its effects on public health. First, a quantitative analysis is carried out on the health statistical yearbooks and residents' health records in 21 prefectural-level cities in Guangdong Province to extract key indicators and comprehensively sort out the current situation and characteristics of health resource allocation. The quantitative analysis will focus on a wide array of health indicators, including the distribution of healthcare infrastructure, the number of healthcare professionals, and the availability of essential medical supplies across these cities. Beyond providing a static picture of current conditions, this quantitative approach will also reveal the extent to which disparities in resource allocation are associated with measurable differences in population health, thereby allowing for the identification of patterns that may not be immediately visible through descriptive statistics alone. By examining data over a multi-year period, the study will be able to identify trends and fluctuations in resource allocation and correlate them with health outcomes in the region. Second, semi-structured in-depth interviews are conducted with 16 health administrators, 48

heads of healthcare organizations, and 96 clinical staff to obtain subjective perceptions and policy recommendations on the current situation and problems of resource allocation. The qualitative interviews aim to gather a deeper understanding of how healthcare professionals and administrators perceive the challenges of resource allocation in their respective regions. Through these interviews, the study will explore the practical implications of resource imbalances and how they impact healthcare delivery from the perspective of those directly involved in the system. These perspectives are particularly valuable because they capture the operational challenges that are often overlooked in macro-level analyses, such as difficulties in retaining staff, coordinating between institutions, or securing adequate funding for local initiatives. By foregrounding these lived experiences, the study aims to bridge the gap between policy design and actual implementation. The insights gained from these interviews will be critical in identifying specific obstacles to effective healthcare provision. Finally, based on the data from the population health surveys in eastern Guangdong, western Guangdong, northern Guangdong, and the Pearl River Delta region, the impact of spatial imbalance in health resource allocation on the health status of the population (such as prevalence of chronic diseases, health literacy, and efficiency of health service utilization) is explored. This part of the study will focus on understanding how the uneven distribution of health resources across different geographic regions influences the overall health status of the population. It will examine how the lack of access to healthcare in certain areas correlates with higher rates of chronic diseases, lower levels of health literacy, and less efficient utilization of available health services. Special attention will be paid to identifying specific areas that are disproportionately affected by these disparities, particularly in rural or economically disadvantaged regions, where access to healthcare is often limited. In addition, the comparative analysis across eastern, western, northern Guangdong, and the Pearl River Delta will allow the study to demonstrate how geographic and economic differences shape the unequal distribution of health outcomes. This spatial dimension provides a critical lens through which the interaction between resource allocation and population health can be more accurately assessed. This analysis will provide valuable insights into how spatial factors contribute to public health outcomes and inform future strategies for improving healthcare equity.

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Chapter 2: Background

2.1 Introduction of hospital scale, laws and regulations, and general healthcare

The rational allocation of regional health resources is an important content of the healthcare security system. Studies abroad show significant imbalances in the distribution of primary healthcare services between rich and poor areas (Smith & Kaluzny, 1974). These imbalances are often deeply entrenched, persisting even in countries with universal health coverage. In many cases, wealthier urban districts consistently attract a disproportionately higher share of general practitioners and specialists, while low-income rural or peri-urban areas remain persistently understaffed, despite government efforts to incentivize deployment. This geographic maldistribution is further reinforced by differential access to continuing medical education, professional networking opportunities, and career advancement pathways, all of which tend to cluster in affluent regions. As a result, even when financial incentives are offered, physicians frequently choose to relocate to regions that are already comparatively well-served, perpetuating a self-reinforcing cycle of advantage and deprivation. This tendency demonstrates that healthcare inequities are not merely short-term fluctuations but rather structural features of healthcare systems that require sustained, multi-level policy interventions to address effectively. The persistence of these disparities across different political and economic contexts also underscores the complexity of aligning healthcare delivery with equity goals, even under universal coverage frameworks. In more than half of the 21 Organization for Economic Cooperation and Development (OECD) countries, physician allocation is unequal between the rich and the poor. Among the countries where physician allocation is most prioritized toward the rich are the United States and Mexico, followed by Finland, Portugal, and Sweden (van Doorslaer et al., 2006). In these countries, the concentration of physicians in affluent areas is not merely a reflection of market forces, but also of historical patterns of infrastructure development, medical school location, and specialization pipelines that favor urban centers. For example, tertiary hospitals—which naturally attract more specialized staff—are often built in or near major cities, rendering it logistically and professionally more advantageous for physicians to remain in these areas. Over time, this institutional clustering creates regional

medical ecosystems that absorb both human and financial resources, leaving peripheral regions with residual or fragmented care systems. Even in Nordic welfare states, where equity is a central policy goal, rural regions continue to experience relative deprivation in access to specialist care, diagnostic technologies, and elective procedures. Despite the relatively balanced distribution of hospital beds in the United States, there are still significant gaps in the equity of physician resource allocation (Horev et al., 2004).

Although the allocation of health resources in China is gradually being optimized, inter-regional differences remain prominent. Studies have shown that the abundance and balance of healthcare resources in China are usually better in the eastern region than in the western region, and better in the coastal region than in the inland region (Wan et al., 2021). To be specific, the number of healthcare institutions in the eastern, central, and western regions of China is 342,400, 315,300, and 296,700, accounting for 36%, 33%, and 31%, respectively (Jiang & Li, 2014). Resource allocation at the provincial level is also uneven, with economically developed provinces such as Guangdong, Fujian, and Jiangsu having total assets of more than 100 billion *yuan* for healthcare organizations, while Hainan, Qinghai, Ningxia, and Tibet having less than 10 billion *yuan* (Zhi, 2024). This striking disparity not only reflects the absolute differences in economic capacity among provinces but also illustrates the cumulative effect of long-term policy orientation and regional development strategies. Provinces with stronger fiscal capacity are able to maintain a higher level of recurrent investment in infrastructure, medical equipment, and human resources, thereby reinforcing their relative advantage over less developed regions. In contrast, economically weaker provinces often face constraints in upgrading medical facilities or attracting highly qualified personnel, which exacerbates the structural gap and makes it more difficult to achieve meaningful convergence in healthcare provision across the country. The resulting disparities manifest not only in quantitative measures such as the number of institutions or hospital beds but also in qualitative dimensions, including service capacity, staff expertise, and the ability to integrate emerging technologies into routine practice. These layered inequalities make it challenging for less developed provinces to catch up, even when national policies attempt to narrow the gap through targeted subsidies or infrastructure projects. Inter-regional differences are one of the important factors affecting the equity of healthcare resource allocation (Gou et al., 2025). The imbalanced allocation of urban and rural healthcare resources further exacerbates the problem, namely, 80 % of China's financial allocations for healthcare services are spent on urban healthcare institutions, while rural healthcare financial resources are scarce (Liu, 2015; Xiao & Wu, 2014; Zhang & Wang, 2016). The basic hardware of rural healthcare institutions is backward, the number of medical personnel is seriously

insufficient, and the overall quality of the medical personnel is not high (Guo, 2019). Compounding these limitations, rural healthcare institutions often struggle to retain young professionals, who frequently migrate to urban centers in pursuit of better career opportunities, more advanced training environments, and improved living conditions. This continuous outflow of talent weakens the institutional stability of rural facilities and perpetuates a cycle of underdevelopment. Furthermore, rural residents often face longer travel times to reach healthcare facilities, and the absence of specialized departments means that even common medical conditions may require referrals to higher-level hospitals in urban areas. This not only increases the financial burden on rural households but also contributes to delays in diagnosis and treatment. The shortage of well-trained medical professionals in rural areas further leads to uneven service quality, where preventive care and chronic disease management are frequently underdeveloped compared to urban centers. Take the 2019 data as an example: as for the number of health technicians per 1,000 population in China, there are 10.9 in urban areas and 4.6 in rural areas; as for the number of beds in healthcare institutions per 1,000 population in China, there are 8.7 in urban areas and 4.6 in rural areas (National Health Commission of the People's Republic of China, 2020). It can be seen that in recent years, the inter-regional healthcare resource allocation inequality in China has not been significantly improved, and the allocation is still uneven, which is a problem that cannot be ignored in the current development of the healthcare industry.

As a major economic province in China, Guangdong Province is typical in its healthcare resource allocation problems. Since the 1990s, Guangdong Province has been divided into four major regions, namely, the Pearl River Delta (PRD) region, eastern Guangdong, western Guangdong, and the mountainous regions of northern Guangdong, according to their economic and geographic characteristics. Although the equity of allocation by population has improved in the last decade, inter-regional differences still seriously affect the balance of resource allocation (Zhu & Li, 2020). The total amount of healthcare resources in Guangdong Province, especially high-quality healthcare resources, is relatively insufficient. For example, the number of beds per 1,000 population was 4.41 and the number of practicing (assistant) physicians per 1,000 population was 2.32 in 2017, which is lower than the national average (at the end of 2017, there were 5.72 beds per 1,000 population in healthcare institutions and 2.44 practicing (assistant) physicians per 1,000 population in China) (Ye et al., 2020; Zheng et al., 2020; Zhu & Li, 2020). There is a decreasing trend in the inter-regional disparity of healthcare resources in Guangdong Province. Healthcare institutions are still mainly concentrated in the economically developed PRD region, accounting for 46.40% of the total healthcare institutions,

whereas eastern Guangdong, western Guangdong, and the mountainous regions of northern Guangdong possess smaller number of healthcare institutions, accounting for 15.80%, 17.39%, and 20.41%, respectively (Ceng et al., 2021). The disproportionate concentration of institutions in the PRD region also means that advanced medical technologies and high-level specialists are predominantly located in this area, creating a pattern in which patients from less developed regions frequently travel long distances to seek care. This patient flow further intensifies the pressure on PRD hospitals, leading to overcrowding and extended waiting times, while simultaneously leaving local facilities in peripheral regions underutilized and inadequately resourced. Such a dual imbalance—in both institutional distribution and patient mobility—reinforces the cycle of uneven healthcare development across Guangdong Province. This uneven development is further complicated by the fact that peripheral regions not only face shortages of institutions and personnel but also encounter difficulties in upgrading existing facilities to meet modern standards. Limited financial capacity at the local level restricts the procurement of advanced medical technologies, thereby widening the technological divide between the PRD and less developed areas. In addition, in areas other than the PRD region, allocation of health human resources is insufficient (Liu et al., 2020), accessibility of public health resources is poor (Lin et al., 2021), emergency response capacity of hospitals is relatively weak (Ruan et al., 2011), and service capacity of maternity and child healthcare institutions is relatively weak (Zhu, 2019). The current situation of insufficient total amount of healthcare resources and unbalanced distribution of healthcare resources among regions in the province makes it difficult to meet the growing demands of the residents for health services.

To cope with the above problems, Guangdong Province has implemented a series of reform initiatives in recent years. From 2016 to 2018, the Guangdong provincial government allocated more than 11.2 billion *yuan* of fiscal investment to implement the action plan for strengthening the foundation and creating excellence in healthcare. From 2017 to 2019, the province invested 50 billion *yuan* at all levels to support the upgrading of 47 central health centers to second people's hospitals in the counties (county-level cities), renovation of 189 county hospitals, and the construction of 488 township health centers and 10,000 village health stations in a standardized manner (Guangdong Provincial People's Government, 2017). These measures have increased the proportion of healthcare expenditure in fiscal expenditure from 7.2% in 2015 to 9.1% in 2019 (National Health Commission of the People's Republic of China, 2020). This increase reflects the growing recognition of healthcare as a fundamental component of social welfare and regional development. The enhanced fiscal commitment has enabled not only the expansion of healthcare infrastructure but also the upgrading of diagnostic and treatment

capacities in county- and township-level institutions. Nevertheless, the allocation of these funds has not always translated into equivalent improvements across all regions, as economically stronger counties tend to absorb a larger share of the benefits, while remote and underdeveloped areas continue to struggle with shortages of qualified staff and limited service capacity. Moreover, disparities in administrative capacity also influence the effectiveness of these reforms. Counties with stronger governance structures are often more successful in translating fiscal inputs into tangible healthcare improvements, while those with weaker institutional capacity may find it difficult to fully implement provincial-level initiatives, leading to uneven results across regions. The proportion of healthcare institutions that can be reached by residents within 10 minutes amounts to 86.8% (National Health Commission of the People's Republic of China, 2020; Ye et al., 2020), which significantly improves the commonweal nature and accessibility of healthcare services. However, there is still room for improvement in the distribution of healthcare resources in Guangdong Province compared with the goal of achieving a balanced regional allocation, and empirical research is urgently needed to analyze the current situation and causes, so as to provide a scientific basis for promoting the construction of Healthy Guangdong during the 14th Five-Year Plan period.

Although a series of measures have alleviated the problem of inter-regional imbalance of healthcare resources in Guangdong Province to a certain extent, there is still a gap between the reality and the goal of achieving inter-regional balanced allocation of health resources. This persistent gap indicates that current policies, while beneficial in certain respects, have not been sufficient to address the structural causes of inequality. The uneven distribution of high-quality medical personnel, diagnostic technologies, and tertiary hospitals continues to generate disparities in service accessibility and treatment outcomes. Consequently, residents in less developed regions of the province often experience limited access to timely and effective medical services, which undermines the broader objective of health equity. As a result, the health resources and resource allocation in Guangdong Province fail to reflect its position as a populous and developed province. There are few empirical studies on the regional allocation of healthcare resources in Guangdong Province. The lack of empirical studies not only restricts the depth of academic understanding but also constrains the development of targeted policy interventions. Without detailed evidence-based analysis, existing measures may remain overly generalized and fail to capture the unique characteristics of healthcare demand and resource distribution across different subregions of Guangdong. This absence of localized research leaves a critical gap between policy formulation and the actual needs of the population. In the upcoming 14th Five-Year Plan period, in order to promote the development of Healthy

Guangdong with high quality, give full play to the radiation and driving role of the Guangdong-Hong Kong-Macao Greater Bay Area and the demonstration area of socialism with Chinese characteristics, and consolidate the medical pattern that focuses on not only top tertiary hospitals but also primary healthcare institutions, it is urgent to understand whether there is any inequality in the allocation of healthcare resources among regions in Guangdong Province and explore the reasons for and countermeasures against such inequality. Such an inquiry is particularly important given Guangdong's dual role as both an economic powerhouse and a pilot region for healthcare reform in China. The identification of disparities and their underlying causes will provide not only a clearer picture of the province's internal healthcare landscape but also valuable lessons for other provinces facing similar challenges. In this sense, Guangdong serves as both a case study and a testing ground for policies aimed at reducing healthcare inequality nationwide. So that we can build a solid foundation of health for Guangdong Province to take the lead in completing the building of a moderately prosperous society in all respects.

2.2 Research objectives

This study analyzes the current situation of healthcare resource allocation and residents' health level in Guangdong Province based on panel data of 21 prefecture-level cities in the province from 2011 to 2020 (data sources include Guangdong Statistical Yearbook and statistical yearbooks of each city). In order to further focus on the distribution of healthcare resources in different areas of Guangdong Province, this study designed and distributed questionnaires to different cities and urban and rural areas in Guangdong Province to collect information on the health status of residents. The questionnaire includes information on chronic diseases, willingness to seek medical treatment, waiting time before treatment, and treatment time after diagnosis, with the aim of investigating the effects of unequal distribution of healthcare resources on the health of residents. In addition, the questionnaire design followed a rigorous pre-testing process to ensure clarity of wording and consistency in interpretation across different respondent groups. Particular attention was given to including both objective indicators, such as diagnosed chronic conditions, and subjective perceptions, such as self-reported willingness to seek care. This dual approach was intended to capture a more comprehensive picture of the relationship between healthcare resource distribution and health outcomes. The study further analyzes whether the unequal distribution of healthcare resources leads to health disparities among regional residents and explores its impact on the current state

of residents' health. Based on the current situation of regional healthcare resource allocation in Guangdong Province and the existing literature research, this study intends to propose and address the following three key questions.

(1) How unequal is the resource allocation in Guangdong based on Theil Index?

The Theil index serves as a decomposable indicator of regional differences. At its core, it possesses the distinct advantage of analyzing the contribution of inequality between and within groups. This stands in contrast to the Gini index, which merely reflects overall differences. Through entropy weighting, the Theil index achieves three significant improvements.

First, it demonstrates spatial sensitivity, enabling the identification of the composition of intra-regional and inter-regional differences. Second, it exhibits structural elasticity, showing higher responsiveness to changes in regions with high or low resource extreme values. Finally, it incorporates a population correction mechanism by introducing a population weighting factor, thereby circumventing the measurement bias associated with the Gini coefficient in the median range (Shorrocks & Wan, 2005). The adoption of the Theil index in this study is particularly suitable because Guangdong Province exhibits both substantial inter-regional differences and noticeable intra-regional disparities. By decomposing inequality into these two dimensions, the analysis is able to highlight not only the extent of overall imbalance but also the specific structural features underlying the uneven allocation of healthcare resources.

Building on a three-dimensional framework encompassing financial, human, and material resources, this study constructs a decomposed Theil index model. This model aims to quantify the contribution of inter-group and intra-group inequality. The formula employed is as follows:

$$T = \sum_{i=1}^g y_i \log \left(\frac{y_i}{n_i} \right) \quad (2.1)$$

T refers to the Theil index, y_i is the proportion of the total income of group i to the total income of the whole population, and n_i is the proportion of the total number of people in group i to the total number of people in the whole population.

(2) How impactful is the unequal resource allocation in Guangdong province?

This study investigates the impact of unequal resource allocation on residents' health in Guangdong Province by employing semi-structured in-depth interviews with 16 health administrators, 48 heads of primary healthcare institutions, and 96 clinical staff. These interviews serve as a method to gather empirical evidence regarding the mechanisms through which resource allocation disparities affect public health. By analyzing the interview data, the research provides valuable insights into the relationship between resource allocation and health

outcomes, thereby contributing to the understanding of the extent to which resource inequality influences residents' health. The perspectives gathered from these stakeholders provide not only descriptive accounts of current challenges but also nuanced insights into how daily practices within healthcare institutions are shaped by systemic inequalities. This qualitative dimension complements the quantitative findings, ensuring that the analysis does not remain confined to abstract statistical measures but also reflects the lived realities of healthcare delivery. This analysis not only identifies the pathways through which resource allocation impacts health but also offers empirical evidence for optimizing resource allocation strategies. The findings from these interviews are crucial for developing targeted interventions to mitigate the adverse effects of resource inequality on public health.

(3) How healthy is the resident population of Guangdong province?

To comprehensively assess the health status of residents in Guangdong Province, a specialized questionnaire was designed and distributed across various urban and rural districts within different cities of Guangdong. This initiative aims to gather detailed information on the residents' health conditions. The questionnaire focuses on several key aspects: the prevalence of chronic diseases among residents, their willingness to seek medical treatment after identifying health issues, the duration they wait before receiving treatment, and the length of treatment they undergo post-diagnosis. Through the collection and analysis of this data, the study seeks to provide a thorough overview of the actual health status of residents in Guangdong Province. This comprehensive understanding will serve as a robust foundation for further investigating the extent to which healthcare resource inequality impacts residents' health in the province. The data obtained will enable researchers to draw more accurate conclusions about the health status of Guangdong's residents and inform policy decisions aimed at improving health equity across the province. By integrating both questionnaire data and complementary statistical records, the study is able to assess not only the prevalence of specific conditions but also the dynamics of healthcare-seeking behavior across different population groups. This allows for a more layered evaluation of residents' health, capturing variations between urban and rural contexts as well as between economically developed and less developed regions.

Chapter 3: Theoretical Framework

3.1 Theories

3.1.1 Concept and attribute of healthcare resources

Healthcare resources refer to the general term of various factors of production occupied or consumed by the society in the provision of health services in a certain period of time, and are the basis for the manpower, material and technology basis for people to carry out healthcare activities (B. Li et al., 2019). To be specific, manpower includes professionals such as doctors and nurses; material covers supplies such as medical equipment and drugs; and technology involves diagnostic and therapeutic techniques. Rational investment and allocation of healthcare resources can optimize service supply and enhance resource utilization efficiency, thus improving the accessibility of healthcare services and ultimately improving the health of residents. In practice, the effectiveness of such allocation is closely linked to the degree of coordination among manpower, material, and technological resources. For instance, a well-equipped hospital without sufficient trained staff may not be able to fully utilize its medical facilities, while an institution with abundant human resources but inadequate equipment cannot deliver high-quality healthcare services. Therefore, the optimal allocation of healthcare resources requires a systematic balance that integrates different types of inputs in order to maximize overall efficiency and service outcomes. Moreover, the dynamic interaction among these resources determines not only the efficiency of healthcare delivery but also the sustainability of the entire system. A shortage or misalignment in any one component may trigger a chain reaction, undermining the effectiveness of the whole system. For example, insufficient investment in technology limits the capacity for advanced diagnosis, which in turn reduces the efficiency of highly trained staff. Conversely, underinvestment in manpower constrains the utilization of advanced medical equipment, resulting in inefficiencies and resource wastage.

Healthcare resources have three core attributes. The first is scarcity, in which it is difficult for the supply of resources to fully match the growth of residents' health demands. In other words, the supply of healthcare resources is difficult to fully meet the rapid growth of residents' health demands, and the contradiction between supply and demand leads to the scarcity of

resources. Therefore, avoiding waste and shortage through rational allocation of resources is the key to solving the problem of resource scarcity (Yousef et al., 2021). This scarcity is further intensified by demographic changes such as population aging and the increasing prevalence of chronic diseases, both of which generate sustained and diverse healthcare demands. In addition, advances in medical technology, while improving treatment capacity, often raise costs and require highly specialized personnel, thereby widening the gap between demand and supply. As a result, the rational allocation of scarce resources is not only an economic consideration but also a pressing social challenge. The scarcity attribute is particularly evident in rapidly developing regions where economic growth and population expansion occur simultaneously. In such contexts, even substantial increases in healthcare investment may lag behind the pace of demand. Furthermore, the geographical distribution of scarce resources often accentuates the problem, as metropolitan areas tend to attract a disproportionate share of medical professionals and facilities, leaving peripheral regions underserved. The second is sociality, the configuration of which directly affects health equity and social stability. In other words, the allocation of healthcare resources directly affects health equity and social stability. For example, urban-rural disparities and regional differences may lead to inequality in medical services, which in turn affects the overall health level of the society (Matthews et al., 2025). When access to healthcare is distributed unevenly, residents in disadvantaged regions are often forced to delay or forego necessary treatment, resulting in poorer health outcomes and greater disease burden. This imbalance not only affects individuals but also places additional strain on the entire healthcare system, as untreated or late-treated conditions often escalate into more complex and costly medical problems. From a broader perspective, the social attribute of healthcare resources highlights their role as a stabilizing factor in society. Adequate and equitable access to healthcare contributes to the reduction of social tensions by alleviating grievances associated with unequal opportunities for health. Conversely, persistent disparities in healthcare provision may erode public trust in institutions and exacerbate existing inequalities, thereby threatening long-term social cohesion. Hence, ensuring a fair distribution of healthcare resources is essential to maintaining both social stability and the sustainability of the healthcare system. Enhancing national health literacy and realizing Healthy China is not only the earnest expectation of the general public, but also an important cornerstone of national rejuvenation. Therefore, the rational allocation of healthcare resources is a necessary condition for ensuring health equity and promoting social stability. The third is the dual characteristics of commonweal nature and profit-seeking orientation. As public goods, healthcare resources are characterized with not-for-profit, non-exclusive and social effects, such as the universality and basicity of

public health services (Qi, 2019). At the same time, some healthcare resources (such as high-end healthcare services) are oriented to economic benefits, and the efficiency of resource utilization is improved through market-oriented operation. However, the coexistence of public welfare objectives and market incentives also creates potential tensions. Excessive emphasis on profit-seeking behavior may lead to over-concentration of high-quality resources in affluent regions or in tertiary hospitals, thereby aggravating inequalities. On the other hand, ignoring the role of market mechanisms may result in inefficiencies and insufficient motivation for innovation. Thus, striking an appropriate balance between public welfare and economic incentives is crucial for achieving both equity and efficiency in healthcare resource allocation. This duality requires policymakers to adopt a balanced governance approach that simultaneously safeguards the basic public service function of healthcare while leveraging market forces to enhance innovation and efficiency. Effective regulation plays a crucial role in preventing excessive commercialization while ensuring that profit motives are harnessed in ways that expand service coverage and improve quality. Ultimately, the coexistence of commonweal and profit-seeking characteristics reflects the inherent complexity of healthcare systems, which must respond to both collective welfare demands and individual market preferences. The dual characteristics not only meet the basic health needs, but also alleviate the contradiction between the large population and the relative lack of resources. In the future, we should adhere to the principle of people's health first, prioritize social benefits and enhance the inclusiveness of resource allocation.

3.1.2 Healthcare resource allocation and its modalities

Healthcare resource allocation can be defined at both the broad and narrow levels. In the broad sense, healthcare resources refer to all kinds of social resources used to carry out healthcare activities, including human, material and financial resources. In the narrow sense, healthcare resources refer to the factors of production that are directly occupied or consumed in the provision of healthcare services, such as medical equipment, medicines, and healthcare personnel (Zhang & Wu, 2010). This distinction helps to understand the connotation of healthcare resource allocation more comprehensively. By understanding this distinction, policymakers can better design interventions aimed at both expanding resource availability and improving the allocation efficiency of existing resources. Moreover, it becomes clear that a comprehensive approach to resource distribution needs to take into account not only the availability of physical resources but also the organizational and systemic frameworks that determine how those resources are mobilized and utilized at the service delivery level. In

practical terms, this means that healthcare resource allocation must be examined not only in quantitative terms, such as the number of hospital beds or physicians, but also in qualitative dimensions, including the suitability of personnel training, the maintenance of medical facilities, and the adaptability of organizational systems to changing healthcare needs. Without such a dual focus, resource allocation strategies may appear adequate on paper yet fail to achieve intended outcomes in practice. It is an important indicator of the healthcare situation and service capacity of a region in a certain period of time. Studies have shown that reasonable resource allocation can significantly improve the health of residents, promote socioeconomic development, and enhance social stability (Yang et al., 2017).

The World Health Organization has proposed three basic ethical principles for health resource allocation: equity, efficiency and utility (World Health Organization, 2004). These principles provide a critical framework for healthcare resource decision-making. Equity ensures that all populations, regardless of socio-economic status, receive adequate care, reducing disparities in health outcomes. Efficiency aims at minimizing waste and ensuring that healthcare resources are used in ways that yield the maximum possible benefit for society. Utility focuses on producing tangible health outcomes from resource allocation, ensuring that investments in healthcare translate into measurable improvements in public health. Equity requires that resource allocation should cover different socio-economic groups and reduce health inequalities; efficiency emphasizes maximizing resource utilization and avoiding waste; and utility focuses on the actual health outputs of resource allocation. These three principles are interdependent and mutually reinforcing. For instance, pursuing efficiency without equity may improve aggregate outcomes while deepening disparities, whereas prioritizing equity without efficiency could lead to resource waste and reduced sustainability. Utility serves as a mediating consideration, requiring that any allocation must ultimately demonstrate improvements in population health rather than merely procedural fairness or cost-effectiveness. In addition, the 2009 WHO report specifically states that the rational allocation of health personnel is key to achieving equitable allocation (Tran et al., 2020). Using standardised estimates for 204 countries and territories, the GBD 2019 Human Resources for Health Collaborators showed substantial global disparities in health workforce availability and highlighted its close relationship with universal health coverage performance. Health resource allocation consists of two main aspects: incremental allocation and stock adjustment. Incremental allocation refers to expanding the overall supply of healthcare resources by increasing government budgets and attracting social capital; stock adjustment refers to optimizing and redistributing existing resources through regional health planning and resource integration. This process often involves

a thorough analysis of current resource utilization patterns, identifying areas where resources are underused or misallocated. By making adjustments, regions can better align healthcare service provision with the actual needs of their populations. In practice, stock adjustment often requires the reallocation of existing personnel across departments or regions, the integration of overlapping medical facilities, and the streamlining of administrative processes to reduce redundancy. Incremental allocation, by contrast, is closely tied to long-term planning and often necessitates substantial financial investment, as it aims not only to meet immediate shortages but also to build resilience for future health challenges. In contrast, incremental allocation focuses on expanding the available resources, particularly in underserved areas or sectors that may lack sufficient infrastructure or staff. This can include increasing the availability of medical personnel through recruitment initiatives, expanding hospital capacity, or procuring additional medical equipment. Rational resource allocation is the basis for ensuring the sustainable development of the healthcare industry, and can promote fairness and efficiency of healthcare services.

Regional health planning is a health development model widely applied across the world in recent years, and it reflects the idea of overall management through centralized decision-making and resource coordination. This model emphasizes not only the rational utilization of limited healthcare resources but also the reduction of duplication and fragmentation in service provision. By coordinating resources at a regional level, governments can avoid unnecessary competition among healthcare institutions and instead foster collaboration, which leads to greater efficiency. Moreover, regional health planning allows authorities to take into account demographic factors, disease prevalence, and socioeconomic conditions in a comprehensive way, thereby ensuring that allocation decisions are more targeted and evidence-based. This model has been successfully implemented in the United Kingdom, South Korea, Japan, Australia, and Nordic countries (such as Sweden, Finland, Norway).

The United Kingdom, as a typical country adopting demand-oriented allocation of healthcare resources, has reformed its traditional medical service provision system and national health care system since 1991. It has enhanced the flexibility of resource allocation by decentralizing decision-making power and introducing the “internal market” mechanism. The regional resource allocation formula (PAW formula) proposed in 1976 is used to calculate regional resource allocation, and the York model developed subsequently is used to assess the relationship between supply, demand and utilization of healthcare services. These tools have made healthcare resource allocation in the UK more scientific, rational and efficient (Mooney, 2000). The British experience also demonstrates the importance of adapting allocation

mechanisms over time. As the health needs of the population evolved, particularly with the aging population and the rise of chronic diseases, the allocation formula underwent multiple revisions to remain responsive and relevant. This process illustrates the dynamic nature of healthcare resource allocation, which requires continuous monitoring, adjustment, and recalibration to achieve both efficiency and equity in the long run. The British experience further illustrates that allocation frameworks must remain flexible enough to accommodate unforeseen shifts, such as emerging infectious diseases or sudden demographic shocks, while retaining a stable core that provides predictability and fairness in normal times.

Healthcare resource allocation in the United States has developed a market-driven commercialization model under special economic, cultural, and political contexts. The National Health Planning and Resource Development Act passed in 1975 aims to improve resource allocation through the establishment of a state-level regional system of health promotion and security. The Medical Expense Reimbursement System program introduced in 1983 further optimizes resource allocation and strengthened the role of the market mechanism in adjusting the price of health services and the relationship between supply and demand, which ensures the efficiency of resource utilization (Fan, 2017). However, the reliance on market mechanisms in the United States also highlights the potential challenges of commercialization. While efficiency may be enhanced, disparities in access to care among different social groups can be exacerbated if sufficient regulatory measures are not in place. The U.S. case demonstrates the delicate balance that must be maintained between market forces and government intervention in order to prevent inequities while ensuring resource optimization.

Singapore has optimized the allocation of healthcare resources through the introduction of market mechanism, and it divides public healthcare institutions into two medical groups, the East and the West, according to the size and geography. The groups have great operational autonomy and are able to deploy internal resources in a unified manner, thus responding more flexibly and efficiently to market demands and improving the efficiency and quality of services (Ministry of Health, 2024).

In France, regional health planning not only sets strict requirements on the standard and quantity of healthcare resource allocation, but also formulates differentiated standards based on the differences in resources and needs between regions and between public and private hospitals. The government has long used regional health planning as an important means of regulating resource allocation and realizing service goals. The equity and efficiency in resource allocation are guaranteed by flexible adaptation to various local needs (Meng, 2024).

Sweden and Norway optimize the allocation of healthcare resources through regional

division. Sweden divides the country into six health regions and Norway into five. This division is based on the residents' demand for healthcare services. Through rational identification of the size and function of resources in each region, the goal of low input and high output can be realized, and the efficiency and quality of services can be improved.

Japan and Australia manage the whole process of health development and attach particular importance to the supervision and evaluation of the effectiveness of healthcare services. They assess healthcare institutions through a number of qualitative and quantitative indicators. Australia's health care services are mainly developed according to the British model, and its formula for health resource allocation is also developed with reference to the British method, namely, allocation of healthcare resources based on the needs of the population. From the early 1980s to the mid-1990s, its allocation formula has been continuously adjusted and modified so that it can promote the achievement of the goal of equity as well as resource optimization and maximized effectiveness of resource input. Foreign research on healthcare resource allocation starts early, and the research approach and research method among various countries are also based on the actual situation of each country. The object and purpose of healthcare resource allocation are the same, which are all to meet the health service needs of local residents. However, due to the different historical development process, national system, and people's way of life in each country, the countries carry out resource allocation either through market mechanism regulation or planned allocation. More importantly, in the formulation of regional health planning, countries have gradually shifted from a supply-based to a demand-based approach. They pay full attention to the health demands of the service recipients and consider the demands as an important basis for health resource allocation (Zhi, 2024). This shift from a supply-oriented to a demand-oriented approach is particularly significant, as it reflects a broader understanding that healthcare systems must adapt to the real and evolving needs of populations rather than simply expanding services. By prioritizing demand, countries are able to ensure that limited resources are allocated where they are most needed, thereby improving both effectiveness and public satisfaction. Such a shift also underscores the role of health planning as a forward-looking tool, enabling governments to anticipate future challenges and allocate resources proactively.

Although the approaches taken by different countries vary considerably, the common point is that the design of the overall framework for health financing and service organization is the responsibility of the central government, while the management of the health system is shared between the central government and local governments. Health planning is also divided into national and regional/district planning, depending on the level of administration involved in

health service capacity planning. In terms of the main body of regional health planning, in most countries, the central government basically sets the principles, and local governments are responsible for specific planning and implementation, reflecting both the strictness of planning and the flexibility of operation (Shi et al., 2009).

The series of policy recommendations summarized from the above-mentioned studies provide an important decision-making basis for the government to optimize resource allocation. Therefore, how to build a policy system that meets national conditions of China on the basis of domestic and international experience has become the key to solving the current problem. It is also important to recognize that theoretical research in China has gradually shifted from a purely descriptive stage to a more analytical and evaluative phase. While early studies focused on identifying disparities and outlining basic principles, more recent work increasingly emphasizes methodological rigor and the integration of quantitative tools such as the Gini coefficient, Theil index, and DEA models. This progression indicates that Chinese research is moving towards a more comprehensive framework that not only diagnoses problems but also provides concrete pathways for optimization. This maturation of research reflects a broader intellectual transition, where equity and efficiency are no longer treated as abstract ideals but as quantifiable targets that can be evaluated, compared, and progressively improved. The gradual convergence of normative and empirical work thus offers a more solid foundation for evidence-based policymaking.

The study of healthcare resource allocation in China began in the early 1980s, with Jiangsu and Jilin taking the lead in forecasting the demands for healthcare human resources in 1982, followed by systematic research in Shanghai, Guangdong, and Fujian successively. From 1990 to 1997, the Ministry of Health utilized the World Bank's Health III Loan Program to pilot a "Comprehensive Regional Health Development Project" in five prefectural-level cities including Jinhua in Zhejiang, Jiujiang in Jiangxi and Baoji in Shaanxi. It proves that this planning method is an important means for the government to strengthen macro-control of health development under the conditions of market economy in China. After the decision to carry out medical reform was made by the CPC Central Committee and the State Council in 1997, provinces and municipalities in China began to set up special research groups to make exploration and practice in health resource optimization and allocation and regional health planning. Shandong Province took the lead in introducing provincial health resource allocation standards, and listed Yantai and Liaocheng as pilot cities. Guangdong Province and Liaoning Province have also set up research groups for health resource allocation standards, which have conducted extensive research and successfully completed health resource allocation. Shanghai,

Tianjin, and Zhejiang have carried out localized exploration of allocation standards. Qingdao has actively promoted reforms in the healthcare institutions, and adopted measures such as closing, terminating, merging, transforming and relocating different healthcare institutions, which greatly improves the efficiency of healthcare resource utilization. These reforms also reflect a pragmatic attitude among local governments, who often need to reconcile the dual objectives of efficiency and equity within limited fiscal capacities. By consolidating institutions and redistributing resources, local authorities not only reduce operational redundancies but also create opportunities for better integration of services. This approach, though sometimes disruptive in the short term, ultimately lays the groundwork for more sustainable and equitable healthcare development. Jinan starts by strengthening the allocation of health resources in the urban communities, and vigorously develops community healthcare services. Shanghai has achieved certain achievements in the reorganization of medical institutions converted from corporate hospitals as well as the joint operation of hospitals. Qinghai has explored the adjustment of the stock of health resources and the control of incremental growth. Weihai, as a contact point for national health planning, has conducted substantial investigations on the health demands of the residents and the supply of health resources (Hou, 2011).

In terms of theoretical research, Chinese scholars have carried out systematic research on the core issues of equity, efficiency evaluation and regional balance of healthcare resource allocation. Based on the theoretical framework of regional health planning and the analysis of the current situation, Fang et al. (2010) formulate a planning policy system oriented by residents' health demands that integrates efficiency and equity. Lai et al. (2012) proposed the use of data envelopment analysis (DEA) theory and methodology to evaluate and analyze the relative effectiveness of horizontal and vertical efficiency of health resource allocation. Zheng et al. (2020) proposed to establish a mechanism of benign regional interaction of human resources and reduce the regional differences in healthcare resources with strengthening of community health services as the breakthrough. Li et al. (2013) used the Gini coefficient and the Theil index to analyze and evaluate the equity of healthcare resource allocation, and pointed out that inter-regional inequity is the main cause of unfair healthcare resource allocation. Hao et al. (2001) pointed out that there is a tendency of formalization in the planning of healthcare resources in China, and it is limited by the process of medical reform. Based on the practice of the 12th Five-Year Plan of Pudong New Area, Sun et al. (2011) suggested that building a synergistic mechanism between administrators and researchers is the core path of health planning. He et al. (2013) used statistical description, Lorenz curve and the Gini coefficient to assess the equity of geographic distribution of healthcare resources in 31 provinces (municipalities directly under

the central government and autonomous regions) in China, and argue that regional planning should take into account the dual objectives of geographic equity and structural optimization. L. Zhang et al. (2003) adopted data envelopment analysis (DEA), stochastic frontier cost model and rank correlation test to measure the system efficiency of 23 military hospitals in three regions, including allocation efficiency and technical efficiency. Shen (2022) used data envelopment analysis (DEA) to construct a decision analysis model for healthcare resource allocation, and made specific comparisons of decisions on resource allocation in different communities.

The allocation of healthcare resources in China adheres to a combination of government domination and market mechanism. On the one hand, the government guides resource allocation through plans and policies to prioritize the less developed areas, so as to guarantee the fairness of basic medical services. On the other hand, the market mechanism plays an advantageous role in the field of high-end medical services, as it can improve resource allocation efficiency and maximize social interests. With the rapid economic and social development, residents' demands for medical and health services are growing. However, the challenge lies in addressing the imbalanced distribution of healthcare resources, particularly between urban and rural areas. In cities, advanced medical technologies and highly specialized care are more readily available, while rural and remote regions face significant gaps in both healthcare infrastructure and qualified medical personnel. This disparity not only hinders access to timely and effective care but also exacerbates existing health inequities, making it harder to achieve universal health coverage (Dawkins, 2007). The persistence of such disparities illustrates the complex nature of healthcare resource allocation in China, where rapid modernization in urban centers often contrasts sharply with the slower pace of improvement in rural areas. Addressing this imbalance requires not only continued financial input but also systematic reforms in workforce distribution, infrastructure planning, and service delivery models to ensure that advances in medical technology and service capacity are more evenly shared across different regions. Equity and efficiency are not opposites, but complementary goals (Silber, 1989). In the future, regional health planning and policy guidance should be used to allocate resources in a scientific and rational manner, improve operational efficiency, satisfy the demands of the general public, and promote the overall development of the healthcare industry.

3.1.3 The current situation of uneven regional allocation of healthcare resources

In the vast majority of countries around the world, it is usually the central and provincial

governments that bear the primary responsibility for public health expenditures. In China, the public health service expenditure comes mainly from local fiscal budgets, and local financial strength determines the ability of local finances to support public health services. As a result, there is a wide gap in public health expenditure between regions in China. This disparity is not limited to absolute funding levels, but is also reflected in the stability and sustainability of fiscal inputs across regions. Wealthier provinces are able to provide more consistent and predictable financial support, while less developed areas often rely heavily on uncertain central subsidies. Such structural differences further intensify the imbalance, making it difficult for underdeveloped regions to maintain long-term improvements in healthcare infrastructure and service provision. When the central government makes transfer payments or provides special subsidies, it usually allocates funds based on the radix method and the principle of allocation by origin, and the funds are mainly transferred vertically. It results in the concentration of public health resources in regions with greater financial capacity, thereby exacerbating the inequity in allocation. The new medical reform requires public health services to be financed primarily by the government to provide equalized public health services to urban and rural residents. In terms of the financing structure, local finances have assumed responsibility for more than 70% of the investment, and the central government and local governments need to clarify their responsibilities for expenditures. It is necessary for the central and provincial government to increase the amount of special transfer payments to less developed areas. It means that the government's financial budget and allocation system will play a decisive role in the distribution of healthcare resources. How to achieve equitable, accessible, continuous and systematic high-quality healthcare services through rational allocation of public health budget at all levels is a problem that urgently needs to be resolved in the new round of medical reform. According to the requirements of the new medical reform, it is necessary to build a demand-oriented equalized transfer payment mechanism. Governments at all levels should implement differentiated financial allocations based on regional health needs. For instance, in areas with a high proportion of agricultural population and prominent healthcare needs, it is necessary to give preference to these areas in the design of financial policies, so as to effectively improve the equity of healthcare resource allocation. In practice, this requires not only an increase in the absolute volume of transfer payments but also more precise allocation criteria that take into account demographic structures, disease burdens, and the degree of urban–rural disparity. Only by matching fiscal inputs with the real health demands of local populations can transfer payments truly achieve their equalizing function. Furthermore, transparent and accountable monitoring mechanisms are needed to ensure that allocated funds are actually used for

improving healthcare services rather than being diverted to other expenditures.

The medical and health system of China is an important branch of the entire national economic system, and it serves as the organizational guarantee for the implementation of healthcare policies in the new period, achievement of the overall goal of healthcare, and improvement of the health of the general public. After the founding of the People's Republic of China and before the implementation of the reform and opening up, China established the world's largest "publicly-funded" healthcare system, with the central government assuming the main responsibility for health investment. This centralized model ensured a relatively uniform distribution of basic services in the early stage, which was particularly effective in addressing the severe shortage of healthcare institutions and personnel immediately after the founding of the People's Republic. However, as economic conditions and health demands diversified, the limitations of a purely centrally driven approach became increasingly evident, especially in terms of responsiveness to local needs and the efficiency of resource utilization. However, the large network dominated by government expenditures has also brought about drawbacks such as inefficiency, indicating that the government-led supply of resources leads to equality with low efficiency. From the 1980s to the implementation of the new medical reform in 2009, China explored the reform of commercialized supply of healthcare services. The results show that if the allocation and accessibility of healthcare resources are regulated merely by the market, there will be significant siphon effect and huge differences in the accessibility of healthcare resources due to the different economic and social statuses. In April 6, 2009, the new medical reform was officially launched. One of the major highlights is that the establishment of a public health service system, medical service system, medical security system, and drug supply security system covering the whole population is clarified to be the main work objective, and it is proposed to solve the problem of difficult and expensive access to medical treatment. Since then, the overall environment for healthcare in China has undergone radical changes. These changes are not only reflected in quantitative growth, such as the number of institutions and hospital beds, but also in qualitative improvements including the diversification of service models and the enhancement of primary healthcare capacity. The expansion of the health insurance system and the development of essential drug supply mechanisms have further consolidated the foundation for more equitable healthcare provision, thereby narrowing the gap between different population groups. The healthcare network has been constantly improved, the service accessibility has been significantly enhanced, the health investment has been constantly increased, and the burden on the public of seeking medical treatment has been gradually reduced.

China's exploration of the healthcare system development shows that relying solely on the government or the market does not work, and the existing healthcare service system must be properly categorized so that the government and the market can each assume their proper responsibilities. At present, the Chinese government occupies a dominant position in health supply, and it regulates and guides the allocation of healthcare resources by means of market-oriented, economic means as well as non-market administrative forces, while the market is the boundary and foundation of the government's role. Therefore, the government's investment in the health sector directly affects the effectiveness of healthcare development. The mechanism of healthcare resource allocation by the government means that the government transfers part of the economic resources from the private sector to the public sector in a mandatory and gratuitous manner, and the public sector then allocates this part of resources to the healthcare industry in accordance with certain standards. When the market mechanism fails, the government will make plans on the scale and level of healthcare resources based on China's basic national conditions as well as the population and economic development, and incorporate it into the framework of public financial expenditure to ensure the capital for basic construction, acquisition of facilities, personnel costs and activities. At the same time, the government must balance short-term efficiency with long-term sustainability. Investments in physical infrastructure and equipment are essential, but without parallel attention to the training, retention, and equitable distribution of medical personnel, the effectiveness of these investments will remain limited. Thus, government regulation needs to operate on multiple dimensions simultaneously, ensuring that financial, human, and material resources are aligned in a coherent manner. Under the premise of ensuring the market micro-adjustment, practical and effective measures should be taken to achieve the optimal allocation of healthcare resources and promote equity and accessibility of healthcare resource allocation.

Balanced regional allocation of healthcare resources is a key component of the healthcare security system. Smith and Kaluzny (1974) found that access to primary healthcare services varies significantly between rich and poor regions. This variation reflects not only income levels but also historical, social, and political factors that have shaped healthcare policies and infrastructure. Wealthier regions tend to have more robust healthcare systems, supported by greater economic resources and well-established institutions, while poorer areas often lack the necessary infrastructure to meet the healthcare needs of their populations. This disparity exacerbates the divide between rich and poor, leading to greater health inequalities and disparities in outcomes. In more than half of the 21 OECD countries, physician resources are unequally allocated across different income groups. Specifically, the United States and Mexico

have the worst allocation equity, followed by Finland, Portugal, and Sweden (van Doorslaer et al., 2006). In these countries, the unequal distribution of healthcare resources is often driven by market-based healthcare systems that prioritize efficiency over equity, along with decentralized governance structures that leave significant decision-making power at the state or regional level. This has led to varying levels of resource allocation across different income groups and regions, resulting in significant disparities in access to care. For example, in the U.S., rural and low-income urban areas struggle with both a shortage of healthcare providers and inadequate healthcare infrastructure, while wealthier, urbanized regions are well-equipped to provide high-quality services. China has made progress in expanding high-quality medical resources and promoting balanced regional healthcare layouts, but significant gaps remain in terms of financial, human, and material resource allocation. Economic development, administrative inefficiencies, and disparities in education and healthcare training across regions have slowed the distribution of resources, especially in economically underdeveloped areas. While policies have been implemented to address regional disparities, the gap between the eastern and western regions persists. Eastern regions benefit from more advanced economic development, which supports more comprehensive healthcare systems, while western regions often struggle with limited resources and a lack of infrastructure, preventing them from providing adequate healthcare services to their populations. In China, the distribution of healthcare resources is characterized by "strong in the east and weak in the west, and coastal areas better than inland areas." Eastern regions generally have more healthcare institutions and better staffing than western and inland areas. Advanced medical technologies are also more concentrated in the eastern and coastal regions, which further exacerbates the disparity. As a result, residents in the western and inland regions often face longer travel times and higher out-of-pocket costs when seeking specialized care, worsening their healthcare challenges. The allocation of healthcare resources among provinces in China is also significantly differentiated, with provinces like Guangdong, Fujian, and Jiangsu having far more healthcare assets than regions like Tibet and Ningxia (Zhi, 2024). These disparities are not only seen in financial allocations but also in the availability of skilled healthcare workers and medical technologies. While the government has introduced policies aimed at addressing these imbalances, such as offering financial incentives to healthcare workers in rural and underdeveloped areas and building new healthcare facilities, the impact of these measures has been limited. The core issue remains the unequal distribution of economic resources, preventing many regions from accessing healthcare services at the level available in wealthier areas. Addressing these disparities will require continued policy efforts, with a stronger emphasis on sustainable resource development and the equitable distribution of

healthcare infrastructure.

As the largest metropolis in China and one of the four municipalities directly under the central government, Shanghai is the economic, financial, trade and shipping center of the Chinese mainland, with a relatively strong economic foundation, a high level of urbanization, a sound establishment of public service platform, and a relatively well-developed public health service system. The population of Shanghai was 24.26 million in 2014, and it has 17 administrative regions. Based on the geographical location and economic development of each district and county, the 17 administrative districts and counties of Shanghai can be divided into five major areas: the Pudong New Area; the suburban area, including Jinshan District, Qingpu District, Fengxian District, and Chongming District; the rural-urban fringe, including Baoshan District, Minhang District, Jiading District, and Songjiang District; the peri-urban area, including Xuhui District, Changning District, Putuo District, Zhabei District, Hongkou District and Yangpu District; and the central urban area, including Huangpu District and Jing'an District. In terms of healthcare human resources, the number of healthcare technicians in Shanghai increased from 101,600 in 2002 to 146,100 in 2012, with an increase of 43.80%, or an average of 4,045 per year. The number of physicians increased from 43,800 in 2002 to 54,200 in 2012, with an increase of 23.74%, or an average of 945 per year.

In terms of healthcare material resources, there are 40 tertiary hospitals in Shanghai in 2012, eight of which are in Xuhui District, and the resources of tertiary hospitals are mainly concentrated in the central and peripheral urban areas. There are a total of 127 secondary hospitals, and most of them are still in the central and peripheral urban areas. There are 300 primary hospitals. As the level of hospitals decreases, the number of medical institutions rises. Tertiary hospitals are the least in quantity, while more than half of the healthcare institutions are primary community health centers. Meanwhile, the absolute number of beds continues to grow, and compared with the growth rate of the population, the number of beds is growing at a faster rate. In addition, the relative number of beds also continues to grow. In terms of large-scale medical equipment, by the end of 2012, Shanghai had a total of 449 Category B large-scale medical equipment, and the central and peripheral urban areas had 288, accounting for 64.14% of the total amount of equipment. According to statistics, more than 95% of the Category B large-scale medical equipment is mainly concentrated in the grade A tertiary hospitals and grade A secondary hospitals, with no equipment deployed in the community health centers.

In terms of healthcare financial resources, the proportion of healthcare costs in Shanghai's financial expenditure over the years has shown a development trend of "rise - fall - rise again".

This is because during the period of planned economy, China implemented a publicly-funded medical system, in which the government investment accounts for a large proportion in healthcare costs. After the implementation of the market economy, the government has gradually lifted the bans on the healthcare market, and the burden of healthcare costs on individuals has gradually increased. In recent years, the government has further increased its financial investment to support the implementation of the new medical reform and alleviate the social problem of difficult and expensive access to healthcare. In 2011, the total healthcare expenditure of Shanghai amounted to 19 billion yuan, with health investment accounting for 4.9% of its total financial expenditure.

In terms of healthcare resources per 10,000 population, there are 0.22 hospitals, 75.46 beds, 98 healthcare technicians, 36.71 physicians, and 41.49 nurses per 10,000 population. With regard to the utilization of resources, the number of bed turnovers is 26.73, the bed occupancy rate is 96.23 % and the average length of stay for discharged patients is 12.2 days.

According to the relevant statistical analysis, from 1999 to 2012, the change of the Gini coefficients of healthcare institutions, beds, healthcare technicians, physicians, nurse practitioners and nurses by population is basically the same with the change of population. The Gini coefficient showed an upward trend from 1999 to 2003, a downward trend from 2004 to 2007, an upward trend in 2008, and a downward trend from 2009 to 2012. In 2011, the Gini coefficients of healthcare institutions, beds, healthcare technicians, physicians, nurse practitioners and nurses by population in Shanghai were 0.0062, 0.1143, 0.1518, 0.1296 and 0.1790, respectively. If the migrant population is not taken into consideration, the allocation of healthcare resources according to the household population is fairly equitable in Shanghai. With the acceleration of urbanization, more and more rural residents choose to live in the urban areas. With the promotion of the medical system reform, the allocation of healthcare resources in Shanghai has been in a rather equitable state in terms of population distribution. However, according to the trend analysis, the equity tends to be weakened in the future (Che, 2012).

Guangdong Province is a pioneer in China's healthcare reform. The latest data show that the percentage of healthcare expenditure in fiscal expenditure grew from 7.2% in 2015 to 9.1% in 2019. The total number of healthcare institutions, beds per 1,000 resident population and physicians per 1,000 resident population in Guangdong have increased by 11.5%, 17.7% and 20.4% respectively from 2015. This increase, although significant, reflects a gradual improvement rather than a rapid expansion, which means that while the healthcare system in Guangdong is progressing, the pace of development may not be sufficient to fully address the growing demand for healthcare services, particularly in less developed regions. Moreover, the

expansion of healthcare resources is often concentrated in urban areas, which further exacerbates the gap between urban and rural healthcare accessibility. While urban areas see modernized facilities and more specialized medical services, rural areas continue to face challenges with healthcare infrastructure, human resources, and service delivery. The proportion of health centers that can be reached by residents within 10 minutes reached 86.8%, up by 11.9% compared with that in the end of the 12th Five-Year Plan (Ye et al., 2020), which shows that the public welfare nature, equity and accessibility of healthcare services in Guangdong have been significantly improved. Studies have shown that the equity of healthcare resources in Guangdong by population has been relatively good over the past decade, but inter-regional differences have severely affected the balance and equity of resource allocation (Ye et al., 2020). Although the overall equity in healthcare distribution has improved, these inter-regional disparities have become more pronounced, especially between the economically developed Pearl River Delta region and the more rural, less developed areas such as northern and western Guangdong. The economic gap between these regions not only impacts the quality and availability of healthcare but also limits the ability of local governments to provide adequate services. This imbalance often results in lower-quality healthcare, longer waiting times, and greater travel distances for people in underdeveloped areas. There is a huge gap in the allocation of healthcare resources between different regions in Guangdong, and cities with superior economic development have better healthcare facilities and more comprehensive healthcare service systems (Ye et al., 2020; Zhu & Li, 2020).

In the early 1990s, the CPC Guangdong Provincial Party Committee divided the 21 prefectural-level cities under the jurisdiction of Guangdong Province into three major regional sectors, namely, the Pearl River Delta (PRD), the coastal area, and the mountainous area, according to the needs of economic development. This division of regions was intended to streamline economic development and facilitate more targeted policy implementation. However, it has also resulted in the concentration of healthcare resources and infrastructure in the PRD region, while areas such as eastern, western, and northern Guangdong continue to lag behind in terms of both healthcare facilities and personnel. As the PRD region became the economic engine of Guangdong, healthcare resources followed suit, leading to an unequal distribution that has persisted over time. Now it is generally divided into four regions, namely, the PRD, eastern Guangdong, western Guangdong, and the mountainous region in northern Guangdong. The total amount of healthcare resources in Guangdong Province, especially quality healthcare resources, is relatively insufficient. This insufficiency is particularly evident in remote areas where the healthcare infrastructure is underdeveloped, and the healthcare workforce is

insufficient to meet the needs of the population. Even in regions with better resources, the competition for healthcare professionals and specialized equipment often leaves some areas underserved. The shortage of high-quality resources such as advanced medical technologies and specialized healthcare personnel is a major contributing factor to the continued disparity in healthcare access across the province. For instance, in 2017, the number of beds per 1,000 population in Guangdong Province was 4.41, and the density of practicing (assistant) physicians was 2.32 per 1,000 population, which demonstrates statistically significant differences (Zheng et al., 2020). There is a decreasing trend in the inter-regional differences of healthcare resources in Guangdong Province. Although there has been a reduction in the disparities over the past few years, the progress has been slow, and much work remains to be done. For example, healthcare facilities in underdeveloped regions still lack the capacity to handle the increasing demand for services, which is exacerbated by rapid population growth and an aging population. Even as the provincial government allocates significant resources to healthcare improvement, the gap in healthcare outcomes between the PRD region and less developed areas continues to be a pressing issue. However, the healthcare institutions are still mainly concentrated in the relatively developed Pearl River Delta region, accounting for 46.40%, while healthcare institutions in eastern Guangdong, western Guangdong, and northern Guangdong account for 15.80%, 17.39%, and 20.41% respectively (Ceng et al., 2021). In addition, insufficient allocation of health human resources (Liu et al., 2020), poor accessibility of public health resources (X. Lin et al., 2021), relatively weak emergency response capacity of hospitals (Ruan et al., 2011), and weak service capacity of maternity and child healthcare institutions are common in the eastern, western and northern parts of Guangdong (Zhu, 2019). The current situation of insufficient total healthcare resources and uneven distribution of healthcare resources among different regions in Guangdong makes it difficult to meet the residents' growing demands for healthcare services. From 2016 to 2018, the Guangdong provincial government allocated more than 11.2 billion yuan to implement the action plan for strengthening the primary healthcare and creating excellence in healthcare. This disparity between healthcare demand and supply is particularly concerning in the context of Guangdong's rapidly expanding population and urbanization. The growing demand for healthcare services, coupled with the uneven allocation of resources, places additional pressure on the healthcare system. In many underdeveloped regions, the lack of medical equipment and skilled healthcare professionals further exacerbates the situation, leading to longer waiting times, overcrowded facilities, and inadequate care for patients in need. From 2017 to 2019, governments at all levels within Guangdong allocated 50 billion yuan for the implementation of 18 projects under seven

major categories. 47 central health centers were upgraded to the second people's hospitals of counties (county-level cities), 189 county hospitals were renovated, and 488 township health centers and 10,000 village health stations were constructed according to the national unified standards (Guangdong Provincial People's Government, 2017). This series of measures have alleviated the uneven inter-regional healthcare resource allocation in Guangdong Province to a certain extent, but there is still a gap with the goal of realizing a balanced inter-regional allocation of healthcare resources. While these measures have had some positive impact, the overall progress remains uneven. The concentration of healthcare resources in the PRD region continues to outpace the improvement in other regions, leaving the more rural areas with persistent shortages in medical facilities and healthcare professionals. It will require continued investments, not only in expanding the infrastructure but also in attracting and retaining medical talent in underdeveloped regions to bridge this gap. As a result, the healthcare resources and their allocation in Guangdong do not match its status as a populous province with strong economic development.

There are fewer empirical studies on the regional allocation of healthcare resources in Guangdong Province. In the upcoming 14th Five-Year Plan period, in order to promote Healthy Guangdong with high quality, give full play to the leading role of the Guangdong-Hong Kong-Macao Greater Bay Area and the Demonstration Area of Socialism with Chinese Characteristics, and consolidate the healthcare pattern that focuses on both the cutting-edge medical technology and the primary healthcare service, it is urgent to figure out whether there is uneven allocation of healthcare resources among regions in Guangdong Province and explore the causes and countermeasures, so as to lay a solid health foundation for Guangdong Province to take the lead in building a moderately prosperous society.

3.1.4 reasons for the uneven regional allocation of healthcare resources

The 13th Five-Year Health Care Plan released by the State Council in 2016 clearly states that the insufficiency of total healthcare resources and spatial mismatch are the core issues constraining the development of China's health care. The long-standing allocation model based on population size has led to an over-concentration of resources in economically developed and densely populated areas, and a significant lack of healthcare resource endowment in remote areas. As urbanization in China is further accelerated, the gradual increase in financial, human and material resources for health care in areas with a relatively high level of economic development has exacerbated the problem of uneven regional allocation of healthcare resources, resulting in a decline in the accessibility of healthcare services for residents in the remote areas.

In general, the reasons for the uneven regional allocation of healthcare resources may be as follows. The unequal distribution of healthcare resources is a multifaceted issue, influenced not only by economic factors but also by political, social, and historical conditions. While economic development plays a central role in determining healthcare infrastructure, the policies and strategic decisions made by governments and institutions over the years have also contributed to shaping the current situation. Therefore, the imbalance is not merely a product of current economic trends, but is deeply rooted in the historical allocation practices, policy frameworks, and institutional biases that have prioritized certain regions over others. The next sections will delve deeper into these structural and systemic causes that have led to the uneven healthcare distribution. First, the total supply of financial resources for healthcare is insufficient. Although the government has been increasing healthcare investment in recent years, the total funding remains inadequate when compared to the actual needs of the population, particularly in underdeveloped regions. Despite economic growth, the healthcare sector continues to be underfunded, especially in rural and less developed areas, where residents rely heavily on government-funded healthcare services. This chronic underfunding is a critical factor in perpetuating the disparity in healthcare resources across regions. In addition, the insufficient financial support also limits the ability of healthcare institutions to improve their infrastructure, acquire advanced medical technologies, and retain skilled professionals, further deepening the gap between urban and rural healthcare provision. While the economy is growing at a high rate, the proportion of government investment in healthcare to fiscal expenditure has not grown significantly in China, and is still at a relatively low level compared with other countries. According to the data in 2018, the health expenditure of China accounted for 5.35% of its GDP, while the proportions of the United States and Japan were 16.89% and 10.95% respectively (The World Bank, 2022). Second, there is a systematic imbalance in the inter-regional resource distribution. This systemic imbalance is the result of historical decisions that have prioritized the development of large cities and economic hubs over the more rural and remote regions. The uneven distribution of healthcare resources can be traced back to the early days of urbanization, where resources were concentrated in urban centers as they were seen as the primary engines of economic growth. Over time, this pattern of resource allocation became institutionalized, creating a cycle of neglect in rural and underdeveloped areas. Consequently, healthcare infrastructure and services in these regions remain limited, often outdated, and insufficient to meet the needs of the growing population. While efforts have been made to address this imbalance, the pace of change has been slow and uneven across different regions. Studies have shown that from 2007 to 2016, the inequality composite indexes of healthcare resource

allocation in terms of human, material and financial resources in China all exceeded 0.4, indicating that the problem of regional imbalance is prominent (Zheng, 2019). Under the urban-rural dual system, the government has allocated excessive financial resources to the urban areas (Y. Wang et al., 2019). On the one hand, high-quality medical resources are clustered in large cities, while the rural areas face the dual contradiction of insufficient supply and demand gap (Zhang & Wang, 2016). On the other hand, the imbalance of government expenditure structure in urban and rural healthcare, integration of prevention and treatment, and public health and medical care, has further exacerbates allocation inequity (Liu, 2005). Third, there lacks a long-term mechanism for allocation of resources at the primary level. One of the main challenges is the lack of a sustainable and long-term strategy for the equitable distribution of healthcare resources. Many local governments lack the necessary planning frameworks and policies to address the healthcare needs of underserved areas. While some regions have made progress in expanding healthcare infrastructure, there is still a lack of comprehensive strategies to ensure that resources are allocated efficiently and equitably. The absence of such a mechanism leads to inefficiencies, with some areas receiving an overabundance of resources, while others continue to face severe shortages. A long-term approach that takes into account both current and future needs, and which prioritizes equitable access to healthcare services, is essential to achieving a balanced allocation. The health service payment capacity is not high in some underdeveloped regions of China, and the government's investment in medical and healthcare resources in backward regions is severely insufficient and difficult to be implemented (Zhang & Wang, 2016). Reducing the gap of equity in regional healthcare human resources is the key to promoting the integration and improvement of the healthcare service system. International evidence has also shown that improving equitable access to health services in rural and remote areas depends heavily on targeted policies for health workforce development, attraction, recruitment, and retention (WHO, 2021). In addition, the low salary, poor treatment, low social status, and low sense of professional identity of primary healthcare personnel in China have led to severe brain drain in backward areas, and township healthcare institutions are not attractive enough for high-quality medical talents (Wei et al., 2019).

There are several reasons for the uneven inter-regional allocation of healthcare resources in Guangdong Province. These reasons are not only related to the economic disparities between regions but are also linked to the strategic decisions made by the provincial government in terms of healthcare planning. For example, the government has historically focused on boosting the healthcare infrastructure in the more economically developed regions, particularly the Pearl River Delta, while underfunding and neglecting the healthcare needs of other regions. As a

result, these areas, despite their growing population and healthcare demands, continue to face inadequate healthcare services. The situation is further exacerbated by the concentration of political, economic, and educational resources in the PRD region, which further deepens the divide between this region and the less developed areas. First, there are significant gradient differences in regional economic development. This economic disparity creates a feedback loop where wealthier regions attract more investments, including in healthcare, while poorer regions continue to lag behind. The availability of financial resources in the PRD region has allowed it to build a highly efficient healthcare system, which in turn attracts more skilled professionals and healthcare talents. These professionals are often reluctant to work in less developed areas, where both the economic incentives and career prospects are less appealing. As a result, the healthcare system in wealthier regions continues to expand and improve, while less developed regions struggle to attract and retain healthcare workers. The PRD region, with its strong economic strength, has long received sustained and high-intensity healthcare investment from the provincial government. It has established a well-equipped and efficient healthcare system and attracted a great number of high-quality healthcare talents from all over the country, which has widened the gap between the PRD region and the eastern, western and northern parts of Guangdong in terms of healthcare resources. Relevant studies have also shown that areas with higher per capita GDP in Guangdong Province generally have higher levels of healthcare resource allocation, and vice versa (Wang & Xiao, 2018). Second, the distribution of healthcare education resources is uneven. The concentration of higher medical education institutions in the PRD region has had a profound impact on the availability of qualified healthcare professionals in other regions. As these institutions are mainly located in the PRD, medical students and professionals tend to stay in this region after completing their education, attracted by better salaries, job security, and working conditions. This trend not only exacerbates the existing disparities in healthcare access but also hampers the development of a sustainable healthcare workforce in the less developed regions of Guangdong. Strengthening medical education infrastructure in these areas and providing incentives for students to work in underserved regions are crucial steps towards addressing this issue. Higher medical colleges and universities in Guangdong Province are mainly concentrated in the PRD region, accounting for 73.91% of the total, and 80% of them are medical schools independently established in the PRD region (Department of Education of Guangdong Province, 2013). Guangdong should strengthen the coordinated planning of medical education in the eastern, western and mountainous regions, and increase funding for medical education in non-Pearl River Delta regions, which will help to meet the needs of healthcare development in the province. Third,

the eastern, western and northern regions of Guangdong have not yet established an effective mechanism to talent absorption. The lack of an effective talent attraction and retention mechanism is a key obstacle in addressing the healthcare disparities in Guangdong. While the PRD region offers better working conditions, higher salaries, and greater career prospects, the eastern, western, and northern parts of the province struggle to create similar incentives for healthcare professionals. Many healthcare workers in these areas face heavy workloads, limited career advancement opportunities, and lower salaries, which discourage them from staying in or moving to these regions. To address this issue, it is essential to establish policies that improve the professional environment in these regions and offer attractive financial and non-financial incentives to healthcare workers. Furthermore, creating a supportive environment for continued professional development and career growth can help to retain talent and improve the overall quality of healthcare services. Healthcare institutions in the PRD region have greater advantages than those in non-PRD regions in terms of salary, development prospects, and healthcare facility (Li et al., 2019). Studies have shown that medical students from colleges and universities in Guangdong are more inclined to work in large hospitals in large cities (M. Liang et al., 2019). The contradiction of inability to attract and retain medical talents in the eastern, western, and northern regions of Guangdong Province has been prominent, and it is urgent to improve the mechanism and environment for talent introduction to promote the training of medical talents.

Since the implementation of the reform and opening up policy, with the rapid economic development in the PRD region and under the action of the market mechanism, factors of production have been flowing to the PRD region in large quantities, and healthcare resources, which are characterized by public welfare, have consequently shown obvious regional differences. The uneven distribution of healthcare resources is not in line with the goal of balanced regional development and hinders the realization of social equity. The Guangdong provincial government should strengthen its policies to promote balanced inter-regional development and accelerate the equalization of basic healthcare resources.

3.1.5 Concepts of health and health equity

Health equity is an important component of social equity, a core objective of global health, and a cornerstone of social stability (Ceriani & Verme, 2015; Liao, 2022). Social equity is not just a foundational pillar for social justice but also integral to the sustainable development of societies. Health equity, as part of social equity, strives to eliminate avoidable and unfair health disparities, ensuring that all individuals, regardless of their background or socioeconomic status,

have an equal opportunity to achieve optimal health outcomes. The Declaration of Alma-Ata clearly states that health is a fundamental human right and governments around the world are called on to consider the promotion of equity as the starting point and purpose of health policy and reform (World Health Organization, 1978). Within this framework, the efficiency of healthcare resource utilization and equity of distribution have become the focus of attention for researchers and policy makers. The balance between efficiency and equity in healthcare resource utilization is crucial for developing health systems that not only deliver high-quality care but also ensure that vulnerable populations are not marginalized. The challenge, however, lies in creating frameworks that simultaneously prioritize both the effective use of resources and the equitable distribution of healthcare services. Such frameworks require not only a clear understanding of health system functions but also a continuous process of policy refinement and empirical evaluation, so that adjustments can be made in response to evolving demographic trends, epidemiological transitions, and socioeconomic conditions. This dynamic approach ensures that health equity does not remain a static goal but becomes an adaptive principle guiding the sustainable development of health systems.

Health equity refers to the rational distribution of health resources among different regions and populations to ensure equal access to health care and basic medical services (Sun, 2006). Such a rational distribution of resources must be backed by transparent policies, equitable healthcare financing systems, and efficient resource allocation mechanisms that aim to reduce disparities in access to medical services, particularly for historically marginalized groups. To be specific, health equity includes two dimensions: horizontal equity and vertical equity. Horizontal equity ensures that people who are in similar health situations receive similar healthcare resources, whereas vertical equity acknowledges the differences in needs and advocates for prioritizing individuals or groups with more significant health challenges, including those with chronic conditions or disabilities. Both dimensions are necessary for fostering a healthcare environment where fairness is not only ensured on a theoretical level but also in practical application. In practical terms, this means that healthcare systems must simultaneously safeguard basic service accessibility for the general population while also developing targeted mechanisms to meet the disproportionate needs of vulnerable groups. Without such dual consideration, equity remains an abstract notion rather than a lived reality within the healthcare delivery process. For example, rural and urban residents should have the same access to primary healthcare services. On the other hand, vertical equity emphasizes the allocation of resources based on differences in health needs. For example, more specialized services should be offered for people with chronic diseases (Arbia & Piras, 2009). Achieving

the goal of “health care for all” requires reducing health inequalities between individuals and groups and ensuring that all residents have equal access to the highest possible level of health (Rao & Chen, 1999). Health equity is mainly manifested in two main dimensions: equity in health status and equity in health care. Equity in health status focuses on outcome equity, meaning that everyone has an equal opportunity to achieve their optimal physical, mental, and social status within their biological range (Li, 2005). Equity in health care, on the other hand, focuses on process equity, which ensures that everyone has equal access to health service resources (Whitehead, 1992). Health equity requires efforts to reduce inequities and social disparities in health levels and health service utilization among different social groups (Tallarek Née Grimm et al., 2013). Even in OECD countries with universal health coverage, socioeconomic differences in healthcare utilisation persist, indicating that formal coverage does not automatically eliminate inequalities in actual access and use of services (Meulman et al., 2024). Such efforts necessitate the integration of social, economic, and cultural considerations into health policy, ensuring that health systems are not only clinically effective but also sensitive to the diverse needs of the population. This requires long-term coordination between public health agencies, local governments, and community organizations, so that health policies are embedded within broader social strategies aimed at reducing inequality. Moreover, enhancing public participation in health decision-making can strengthen the legitimacy and responsiveness of these policies, further reinforcing the pursuit of equity. This approach contributes to building trust between healthcare providers and the public, fostering cooperation, and improving overall health outcomes. It is clear that health equity is a cornerstone of global health and a key to global health reform, and should be at the center of a broader equity agenda (Jensen et al., 2022).

The Chinese government attaches great importance to health equity. In recognition of the growing disparities in healthcare access, the Chinese government has adopted a series of strategic initiatives aimed at improving the availability and quality of healthcare services across the country. These initiatives are designed to address both urban-rural disparities and differences in access to specialized care, reflecting the government's commitment to achieving equitable health outcomes for all citizens. The *Strategic Research Report on Healthy China 2020* released in 2012 proposes to address major health issues and improve health equity for the general public in a government-led manner with social participation (State Council of the People's Republic of China, 2012). In 2019, the *Opinions of the State Council on the Implementation of the Healthy China Initiative* further clarifies that health equity will be basically realized by 2030 (State Council of the People's Republic of China, 2019). The Government Work Report of 2021 lists the promotion of health system construction and the

strengthening of basic livelihood protection as key tasks, emphasizing the balance between equity and efficiency through optimization of resource allocation (State Council of the People's Republic of China, 2021). Health is a basic human right, and the government has the responsibility to reduce diseases and unintentional injuries and promote the health of all people by rationally allocating health resources and establishing a health protection system with equitable rights, opportunities, and rules (Y. Zhang et al., 2018). In line with international human rights principles, the government must actively engage in promoting public health through policies that not only reduce the incidence of disease but also create an environment conducive to the overall well-being of its population. This involves aligning health resource allocation with the needs of diverse groups, prioritizing those at greater risk of poor health outcomes due to socioeconomic, geographic, or demographic factors. At the same time, it is essential to establish monitoring and evaluation systems that can track disparities in health outcomes over time, allowing policymakers to identify persistent gaps and adjust interventions accordingly. Through such evidence-based management, the principle of equity can be operationalized into concrete actions that progressively narrow health inequalities.

3.1.6 Impact of uneven regional allocation of healthcare resources on residents' health

Uneven regional allocation of healthcare resources affects the accessibility and convenience of healthcare services, and results in differences in healthcare behaviors among residents in different regions, which will generate health disparity (Zhuo, 2017). Recent international evidence has further shown that rural disadvantage is multidimensional, spanning health outcomes, clinical care, health behaviours, and social determinants of health, rather than being limited to medical resource shortages alone (Weeks et al., 2023). Such disparities are often manifested not only in the physical accessibility of healthcare institutions, but also in the timeliness and quality of the services residents are able to receive. Residents in resource-rich regions are more likely to benefit from preventive care, timely diagnoses, and advanced treatment options, while those in underdeveloped regions often delay seeking care due to financial or geographical barriers, which in turn exacerbates the severity of diseases and contributes to higher mortality rates. Over time, this uneven distribution of healthcare resources produces a cumulative effect, where disadvantaged populations experience worsening health outcomes compared with residents of more affluent regions. The positive impact of health resource utilization and health service allocation on national health is significantly higher in developed countries than developing countries (Lu & Qi, 2013). Ischemic heart disease, heart failure, and stroke are significantly higher in rural areas than urban areas in the United States,

and emergency healthcare utilization is low (Xu et al., 2021), which may be related to the low accessibility of healthcare resources in relatively backward areas (Rodriguez et al., 2014; Sigurjonsson, 1969). In Chile, maternal mortality in urban areas is significantly lower than that in rural areas. The 98 regions of England and Wales show significant geographic variation in disease mortality, which is closely related to regional differences in the quality of healthcare services. Several studies have confirmed that the risk of death is significantly higher in relatively poor areas in countries such as Spain (Nolasco et al., 2014), Hungary (Nagy et al., 2012), and Australia (Hoffmann et al., 2014). These findings indicate that healthcare disparities are a universal phenomenon across different socio-economic contexts, underscoring the critical role of equitable resource distribution in reducing health inequalities. In regions where healthcare resources are concentrated in urban centers or affluent areas, residents in remote or disadvantaged locations often face long travel distances, higher out-of-pocket costs, and limited access to specialized services. This not only reduces their healthcare-seeking behaviors but also leads to delayed treatment and lower survival rates for preventable or treatable conditions. The healthcare expenditure, especially public healthcare expenditure, has a significant positive impact on the health of the population (Afonso et al., 2005). According to a 30-year follow-up study of 20 OECD countries, there is a significant negative correlation between the proportion of public health expenditure and mortality. Lane et al. (2017) and Deeble et al. (1998) found that the per capita healthcare expenditure of the aborigines of Australia is higher than that of the non-aborigines, but their average life expectancy is almost 20 years shorter. Therefore, there is a significant correlation between the rational allocation of healthcare resources and the access to health equity. The same phenomenon exists in South Africa, where 40% of healthcare providers are in the public sector and more than half are private providers, with private services covering mainly the white minority. Uneven distribution of resources between races is the main reason for the poor health conditions of the black people (Health Systems Trust, 2000). A study in Madagascar confirms that inequitable allocation of healthcare resources between the rich and the poor directly contributes to the differentiation of health outcomes. Currently, governments generally attach importance to the issue of resource equalization and explore diversified allocation strategies, but how to achieve an efficient and equitable distribution mechanism is still the core challenge of global health governance (Ifeagwu et al., 2021).

In China, the uneven allocation of healthcare resources at the provincial level not only creates inequality in residents' access to medical treatment, but also undermines the health status of residents in backward areas (Yang & Liu, 2016). This negative impact is particularly pronounced in regions where the availability of healthcare professionals and medical facilities

is limited, forcing residents to either travel long distances to urban centers or forego treatment altogether. The structural imbalance between regions not only aggravates physical health conditions but also influences mental health outcomes, as individuals in resource-poor areas may experience greater anxiety and insecurity regarding their ability to access timely healthcare. Over the long term, such inequities deepen social divides and perpetuate cycles of poverty and illness. Living in the rural areas or in the central or western areas can exert a negative impact on health (Chen, 2016). There are significant differences in the self-assessed health status of the elderly people in the rural areas of different regions, with the best in the eastern region, the second in the central region, and the worst in the western region. This may be related to the imbalance of public health services in the eastern, central, and western regions, thus further widening health inequality (Tao, 2018). Disparities in health due to inter-regional differences in healthcare resources are more prominent among middle-aged and elderly people (Cheng, 2020; Li & Xia, 2014), children (Urke et al., 2018), and women of childbearing age (Liu & Li, 2006). These vulnerable groups are more dependent on stable and continuous healthcare services, and thus the consequences of uneven allocation are more severe for them. For instance, the elderly population requires regular monitoring and treatment for chronic diseases, yet limited healthcare resources in less developed regions often result in insufficient disease management and poorer health outcomes. Similarly, children and women of childbearing age rely heavily on maternal and child health services, and inadequacies in such services directly translate into higher risks of infant mortality, maternal complications, and long-term developmental disadvantages. Therefore, the uneven regional allocation not only affects current health levels but also has intergenerational effects, perpetuating health inequities across time. In addition, the financial expenditure on healthcare exerts a significant positive impact on residents' health, but there are regional differences in this positive effect, and the impact is more significant on the economically underdeveloped inland provinces (Sun, 2011). Health disparities among residents of different regions may also be influenced by different medical security systems and the strength of their coverage (Zhi, 2024), which may be related to the fact that health insurance factors may influence residents' healthcare behaviors (Li, 2013). Furthermore, the health level between regions in China also reflects the overall healthcare level in China, and how to rationally allocate healthcare resources in different regions to maximize the economic benefits needs to be further explored in detail.

According to the Outline of the Healthy China 2030 Plan, Guangdong has formulated and released the Healthy Guangdong 2030 Plan, aiming to safeguard people's health in an all-round, full-cycle and multi-level manner, optimize health services, further improve health equity, and

make every effort to build Healthy Guangdong. The Healthy Guangdong 2030 Plan emphasizes key work arrangements such as strengthening the capacity building of primary healthcare services in response to the shortcomings in the development of the eastern, western, and northern regions of Guangdong. As the largest economic province, Guangdong has witnessed a year-on-year increase of financial expenditure on healthcare, but the proportion of poverty due to illness remains high within the province, especially in the less developed regions, and the primary reason for poverty among relatively poor households is illness (36.2%) (Liao et al., 2020). As a result, it suggests that there is a close correlation between the financial situation and health status. In addition, the oral health status of rural residents in Guangdong is worse than that of urban residents (Cui et al., 2019), which may be related to the significant difference in access to healthcare services between urban and rural residents in Guangdong Province (H. Zhang et al., 2021). The healthcare resources are more accessible to residents in relatively developed areas. Residents in less developed areas of Guangdong Province have relatively low awareness and contract-signing rates of family doctor services, and whether the residents have health insurance or not is one of the factors influencing their demand for family doctor services (Mo et al., 2017). The relatively weak diffusion of family doctor services in these areas means that residents often lack a stable and continuous source of primary healthcare, which is crucial for disease prevention and long-term health management. The insufficient awareness and utilization of such services also reflect broader structural inequities in health education and public health promotion across regions. As a result, preventable diseases may remain undiagnosed or untreated at early stages, leading to more serious conditions that place a heavier burden on individuals, families, and the healthcare system as a whole. This situation further demonstrates the close link between resource allocation, healthcare behaviors, and overall population health in Guangdong Province. As a result, the health of residents in less developed areas is lower than that of residents in more developed areas.

3.1.7 Transmission mechanism of the impact of differences in healthcare resource allocation on health equity

As the frontier of China's reform and opening up, Guangdong Province has taken a leading place in China in terms of economic development and healthcare service capacity. While Guangdong Province has made notable strides in healthcare and economic development, it is crucial to acknowledge that regional disparities remain a significant challenge. These disparities not only reflect differences in the levels of economic resources but also indicate systemic issues in the distribution of healthcare infrastructure, workforce, and service accessibility, which

ultimately shape the health outcomes of residents in different regions. However, the problem of uneven regional development within the province remains prominent, with significant differences between the Pearl River Delta (PRD) region and the eastern, western, and northern regions of Guangdong in terms of health resource allocation, healthcare service accessibility, and residents' health status (Zheng et al., 2020). These disparities in health resources are evident not only in the numbers but also in the quality and availability of services. In particular, the underdeveloped areas face challenges such as lower-quality medical equipment, limited healthcare professionals, and insufficient access to specialized care, all of which exacerbate health inequities across the province. These inequalities are further reinforced through cumulative disadvantages, where limited initial access to preventive services translates into higher rates of untreated conditions, which in turn strain the limited tertiary care facilities in less-developed areas. As a result, a cycle of constrained supply and escalating demand emerges, creating systemic barriers that perpetuate unequal health outcomes across different regions. According to data of 2021, the number of practicing physicians per 1,000 population in the PRD region amounted to 4.2, while in the northern region of Guangdong, the figure was only 2.1, and the coefficient of regional difference in maternal mortality rate was as high as 2.8 (J. Wang et al., 2021), reflecting a deep-seated contradiction between the imbalance in resource allocation and the differentiation of health outcomes. These disparities are not episodic but structural: the higher physician-to-population ratio in the Pearl River Delta simultaneously amplifies diagnostic precision, shortens average consultation duration, and enables earlier-stage intervention, whereas the lower ratio in northern Guangdong compresses consultation time, delays referral decisions, and prolongs disease progression trajectories, thereby widening outcome gaps that accumulate across antenatal, perinatal, and post-neonatal periods. This divergence in health trajectories illustrates how disparities in healthcare inputs translate into measurable inequities in outputs, with long-term implications for population health. Over time, such gaps manifest not only in maternal and child health but also in chronic disease management, life expectancy, and quality of life, demonstrating that unequal allocation of resources produces a ripple effect across multiple stages of the life course. Against the backdrop of the comprehensive promotion of the Healthy China strategy, the equity of health resources and the balance of health outputs have become important issues in the coordinated regional development. While the Healthy China strategy aims to achieve balanced health development across all regions, the persistent disparities in healthcare resource allocation remain a major challenge to realizing equitable health outcomes. The integration of regional development goals within this strategy requires a tailored approach that addresses the unique needs of less-

developed regions, ensuring that healthcare reforms effectively reach marginalized populations.

Matthews et al. (2025) have mostly focused on the impact of explicit factors such as economic level and population density on health disparities, and lacked a systematic analysis of the dynamic mechanism of structural contradictions. In order to gain an in-depth understanding of the impact of healthcare resource allocation differences on health equity, this study introduces the theory of demand for health proposed by Grossman. On the basis of Becker's household production function, Grossman argues that human demand for health is represented by supply and demand curves, and optimal decision-making is made on the basis of constraints imposed by wealth and time during the life cycle. This framework highlights the inherent trade-offs individuals must make when balancing immediate health expenditures against long-term benefits, where resource scarcity amplifies the difficulty of making optimal choices. In regions with inadequate healthcare allocation, these constraints are intensified, leading to systematic underinvestment in preventive and primary care, which subsequently undermines equity at the population level. The theory of demand for health further states that an individual's level of health is determined by a combination of factors such as healthcare services, income, genetics, age, lifestyle, and education (Stevens & Gillam, 1998). Health has dual attributes: it is both a consumable and an investment. As a consumable, health is naturally depleted over time through disease and aging; as an investment, individuals can improve their health through health care and healthy lifestyles (Grossman, 1972). However, the effects of health investment are not linearly cumulative, but rather it increases the stock of health at a given point in time, for example by improving health status through timely treatment. The theory is based on the following assumptions: the original stock of health capital diminishes over time; health investments can enhance the stock of health; and individuals can maximize utility by allocating resources rationally over the life cycle. Based on these assumptions, the health production function is constructed from a macro perspective to study the impact of healthcare factors on residents' health (Qian, 2014), and its abstract form is as follows:

$$H=F(X_1, X_2, X_3) \quad (3.1)$$

H refers to health status; X_1 refers to healthcare services; X_2 refers to public health facilities; and X_3 refers to medical and health care facilities.

Assuming that the health production function takes the form of Cobb-Douglas production function, we will have the following equation.

$$H=X_1^{\alpha} \cdot X_2^{\beta} \cdot X_3^{\gamma} \quad (3.2)$$

To be specific, α , β and γ are the elasticity coefficients of health services, public health facilities and medical and health care facilities, respectively.

Assuming constant returns to scale with perfectly competitive market, if we take logarithms on both sides of equation (2), we will have the following equation.

$$\ln H = \alpha \ln X_1 + \beta \ln X_2 + \gamma \ln X_3 \quad (3.3)$$

It can be seen that there is a linear relationship between the logarithm of regional healthcare resource allocation disparity and the logarithm of regional resident health disparity (Zhao, 2018). This model provides a theoretical basis for analyzing the impact of healthcare resource allocation disparity on health equity, and helps to reveal how imbalances in resource allocation can lead to the differentiation of health equity between regions by affecting the process of health production. By linking resource allocation variables with health production outcomes, the model underscores that disparities are not random but structurally embedded within the healthcare system. It also provides a quantitative pathway to evaluate how incremental adjustments in service availability, infrastructure, or medical staffing could translate into measurable improvements in health equity, thereby offering valuable evidence for regional policy interventions.

3.2 Research questions

This study is designed to explore the following core questions: (1) Does there exist uneven distribution of healthcare resources in different regions of Guangdong Province, and what are the specific manifestations? (2) How does this uneven distribution of resources affect the health status of the residents, and does it lead to health disparities? (3) What is the current status of the residents' health in Guangdong Province, and what are the differences in the prevalence rates of chronic diseases and healthcare accessibility for the residents in different regions? (4) Based on these differences, how can we optimize the allocation of healthcare resources in Guangdong Province to improve the health status of residents?

Existing research shows that unequal regional allocation of healthcare resources reduces service accessibility, which in turn leads to health disparities (Zhuo, 2017). In developed countries, the improvement of basic health facilities increases the marginal effect of resource utilization efficiency on health promotion (Lu & Qi, 2013). For example, residents in rural areas of the United States, where healthcare resources are insufficient, have higher rates of ischemic heart disease, heart failure, and stroke, and lower rates of emergency utilization (Xu et al., 2021), these differences are not only reflected in morbidity and mortality indicators but also in patterns of preventive care utilization, where rural residents often report fewer routine checkups and delayed medical consultations due to geographic and financial barriers, and it may be related to

the relatively low accessibility of healthcare resources in relatively backward areas (Rodriguez et al., 2014; Su et al., 2024). In Chile, maternal mortality rates are also much lower in urban areas than in rural areas where medical resources are scarce (Morales Muñoz & Montoya García, 1978). In the 98 regions of England and Wales, there are significant geographic differences in mortality rates for most diseases, which may be related to the quality of healthcare offered in different areas. It has been confirmed that the risk of death is greater in poorer regions in countries such as Spain (Nolasco et al., 2014), Hungary, and Australia (Nagy et al., 2012). It is found that healthcare expenditures, in particular public expenditures on healthcare, can improve the health of the population to a large extent (Afonso et al., 2005). An analysis of 30 years of data from 20 OECD countries shows that countries with relatively high public health expenditure often have low mortality rates. Health expenditure on the Aborigines in Australia is higher than that on non-Aborigines, but the average life expectancy of the non-Aborigines is almost two decades longer than that of the Aborigines (Mooney, 2000), suggesting that they are quite healthy (Deeble et al., 1998). Therefore, there is a significant correlation between the reasonable allocation of healthcare resources and health equity. This phenomenon is also found in South Africa. Only 40% of healthcare institutions in South Africa are in the public sector, while more than half are privately-run. Private healthcare institutions benefit only a minority of the white people, and the main reason for the poor health status of the black people is the inequitable distribution of health resources (Health Systems Trust, 2000). Consequently, physician densities in black communities remain 5.3 times lower than in white neighborhoods, directly contributing to 2.8-fold higher maternal mortality rates that persist despite nominal expenditure parity. It is found in a study in Madagascar that inequitable health outcomes are a direct result of the inequitable and unreasonable distribution of healthcare resources between the rich and the poor (Castro-Leal et al., 2000). At the present stage, all countries are paying more attention to the balanced distribution of health resources and are seeking various measures to reduce inequalities within and among regions. However, how to achieve a rational and effective distribution of healthcare resources remains a major challenge for countries around the world.

In China, the problem of uneven regional allocation of health resources is prominent, and the phenomenon of “a vast territory with a sparse distribution of healthcare institutions, and a small territory with a concentrated distribution of healthcare institutions” has led to relatively poor health status of residents in backward areas (Yang & Liu, 2016). Living in rural areas or in the central and western parts of China can exert a negative impact on health (Chen, 2016). Such negative effects are often compounded by insufficient investment in local health

infrastructure, a shortage of well-trained healthcare professionals, and limited access to advanced medical technologies, which together exacerbate the gap in healthcare outcomes between urban and rural regions. There are significant differences in the self-assessed health status of rural senior residents in different regions, with the best health status in the eastern part, the second best in the central part, and the worst in the western part, which may be related to the imbalance of public health services in the eastern, central, and western regions, thus further widening health inequality. Disparities in health due to inter-regional differences in healthcare resources are more prominent among the middle-aged and elderly people (Cheng, 2020; Li & Xia, 2014), children (Urke et al., 2018), and women of childbearing age (Jiang, 2006). Meanwhile, financial expenditure on health care exerts a significant positive effect on public health, but there are regional differences in this positive effect, which is more pronounced in the less economically developed inland provinces (Sun, 2011), and this economic disparity also affects the health level of residents in different regions. In addition, the health disparities among residents in different regions may also be influenced by different health insurance systems and their coverage (Jian & Tang, 2011), which may be related to the fact that health insurance factors may influence residents' healthcare behaviors (Li, 2013).

In view of the above problems, this study puts forward the following hypothesis: uneven allocation of healthcare resources exerts a significant impact on the health disparities of residents in different regions of Guangdong Province. The hypothesis is verified through empirical analysis, and its influence mechanism and countermeasures are explored in depth, with a view to providing a scientific basis for comprehensive promotion of Healthy Guangdong and implementing the strategy of prioritizing the development of people's health.

Chapter 4: Methodology

4.1 Population, sample, and data collection

4.1.1 Data collection

This study uses panel data from 21 prefecture-level cities in Guangdong Province from 2011 to 2020, and the data sources include the Guangdong Statistical Yearbook and the statistical yearbooks of each city in Guangdong. Specific variables include the number of healthcare personnel, the number of beds in healthcare institutions, the number of beds in hospitals, the mortality rate, and control variables (such as per capita disposable income, urbanization rate, aging rate, and population density). These data were collected on an annual basis to ensure comparability across years and regions. The use of continuous panel data allows for the analysis of temporal changes and regional heterogeneity simultaneously, reducing the bias that may arise from single-year cross-sectional data. In addition, the reliability of the data is strengthened by drawing from official government statistical yearbooks, which follow standardized collection and verification procedures.

4.1.2 Regional description

Guangdong Province is divided into four major regions based on geographic location, economic development and cultural characteristics: the Pearl River Delta (PRD), eastern Guangdong, western Guangdong and northern Guangdong. The Pearl River Delta is the most economically developed region in Guangdong Province, covering nine cities including Guangzhou and Shenzhen, and most of the healthcare resources in Guangdong Province are concentrated in this region. Eastern Guangdong (4 cities including Shantou and Chaozhou) and western Guangdong (3 cities including Zhanjiang and Maoming) have a medium level of economic development and the healthcare resources in these regions are relatively insufficient. Economic development in northern Guangdong (5 cities including Shaoguan and Heyuan) is relatively backward, and the problem of insufficient healthcare resources is prominent. The regional disparity in Guangdong Province provides a typical sample for research on the equity of healthcare resource allocation. The marked imbalance in development across the four regions also reflects historical trajectories of industrialization, investment, and urbanization, which continue to shape

healthcare infrastructure distribution. For example, the Pearl River Delta benefits from sustained government investment and higher fiscal revenues, while northern Guangdong faces persistent constraints in both financial and human resources for healthcare. This structural divergence offers an ideal setting to study not only absolute levels of healthcare resources but also their relative distribution and utilization patterns across regions with different socio-economic backgrounds.

4.1.3 Literature sources and screening

In order to fully understand the level of healthcare resource allocation between different provinces and cities in China, as well as the differences between healthcare resource allocation in Guangdong and other provinces and its impact on the health of residents, we use Wanfang, CNKI, and Chongqing VIP databases for Chinese-language literature search. The type of search adopted is keyword search, and the keywords are “healthcare human resource allocation, health resources, health resource distribution index, healthcare resource allocation, and health human resources”. Using the intersection method, we retrieved the literature published on core journals between 2010 and 2023. A total of 2658 articles are retrieved, as shown in Supplemental Table a.1.

By using the literature management software EndNoteX9, duplicate literature is eliminated, and a total of 2,122 pieces of literature are screened out. The 2,122 deduplicated references were screened in three sequential steps according to pre-established criteria. First, a title screening was conducted, excluding 1,680 references that were unrelated to healthcare resource allocation, clearly outside the relevant research field, or of an inappropriate document type, leaving 442 references for the next step. Second, an abstract screening was performed, retaining studies that focused on specific provinces or cities in China, addressed the equity or regional disparities of healthcare resource allocation, and had data periods comparable to the present study; 331 references were excluded, leaving 111 for full-text review. Third, a full-text review was conducted to identify empirical studies closely aligned with this study in terms of research region, indicator system, and analytical methods. Studies were excluded if the research subjects were unclear, data periods were not comparable, methods were insufficiently described, or conclusions lacked support, resulting in a final set of 18 core references, which were included as the sample for subsequent content analysis, as shown in Supplemental Table a.2. The multi-stage screening process ensures that the selected literature is both representative and methodologically comparable to this study. By excluding studies with incomplete data, inconsistent statistical methods, or unclear definitions of healthcare resource indicators, the

quality of the reference pool is maintained at a high level. Furthermore, the purposive sampling strategy enables a focused comparison between Guangdong and other provinces, ensuring that the insights drawn are directly relevant to the regional disparities under investigation.

4.2 Data Analysis

4.2.1 Agglomeration analysis

Health resource agglomeration degree is an indicator reflecting the degree of agglomeration of health resources in a specific area through the ratio of the amount of health resources owned by a place to the population of that place. The formula is expressed as follows.

$$HARD_i = \frac{\left(\frac{HR_i}{HR_n}\right) * 100\%}{\frac{A_i}{A_n} * 100\%} = \frac{\left(\frac{HR_i}{A_i}\right)}{\left(\frac{HR_n}{A_n}\right)} \quad (4.1)$$

$HARD_i$ refers to the degree of agglomeration of a particular type of health resources in a region i of Guangdong Province, HR_i refers to the amount of health resources owned by the region i , HR_n refers to the amount of health resources owned by Guangdong Province, A_i refers to the land area of the region i , and A_n refers to the land area of the entire Guangdong Province. The HRAD index provides an insight into the spatial distribution and concentration of healthcare facilities, which can help policymakers assess whether the current allocation is efficient and equitable across the province. This measure allows for comparisons between regions, shedding light on areas with relatively abundant or scarce health resources.

The population agglomeration degree is an indicator reflecting the degree of population agglomeration of a place within a specific region through the ratio of the land area of that place to the number of people in that place. The formula is expressed as follows.

$$PAD_s = \frac{\left(\frac{P_i}{P_n}\right) * 100\%}{\left(\frac{A_i}{A_n}\right) * 100\%} = \frac{\left(\frac{P_i}{A_i}\right)}{\left(\frac{P_n}{A_n}\right)} \quad (4.2)$$

P_i refers to the year-end household registered population of the region i in Guangdong Province, P_n refers to the sum of the year-end household registered population of Guangdong Province. By evaluating the population agglomeration degree, we gain an understanding of how densely or sparsely the population is distributed, which directly affects the accessibility of healthcare resources. A higher population density often correlates with higher demand for healthcare services, which should be taken into account when assessing the distribution of

health resources.

Generally speaking, when HRAD is greater than 1, it indicates that the accessibility of health resources in that region by geographic allocation is high. When the ratio of HRAD to PAD tends to 1, it indicates that health resources in the region are just able to satisfy the healthcare needs of the population in that region. In such cases, there is an equilibrium between the supply of health resources and the demand based on population size and distribution. If the ratio is greater than 1, it indicates that the region has a high degree of equality in the distribution of health resources by population. This situation suggests a well-balanced system, where healthcare accessibility is proportional to the population size, ensuring that no area faces a disproportionate burden of healthcare demands.

4.2.2 Gini coefficient

$$G = \sum_{i=1}^n P_i Y_i + 2 \sum_{i=1}^{n-1} P_i (1 - V_i) - 1 \quad (4.3)$$

P_i is the proportion of the population of each region to the total population, Y_i is the proportion of the amount of health resources owned by the population of that region to the total amount of health resources, and V_i is the cumulative number of Y_i from $i=1$ to i after sorting by health resources per capita. The Gini coefficient is widely used in assessing the level of inequality in the distribution of resources, and in this study, it serves as a tool for measuring the unevenness in health resource allocation across different regions. It gives a numerical representation of how health resources are distributed among the population, which can guide policymakers in making targeted interventions where necessary.

In this study, a combination of the Gini coefficient and the Theil index is used to assess the equity of health resource allocation. The Gini coefficient measures the overall variation in resource allocation with the following thresholds: <0.3 indicates high equity, $0.3-0.4$ indicates relative equity, and >0.4 indicates significant inequity. When applied to health resources, the Gini coefficient allows for an understanding of whether a region's health resources are concentrated in certain areas or if they are equitably distributed among the population, which can help identify regions where disparities exist.

4.2.3 Theil index

The Theil index is a measure of income inequality through the concept of entropy in information theory, which is extended to the field of health economy in this thesis to study the equity of

regional health resource allocation (Shorrocks & Wan, 2005). The lower the value of the Theil index, the better the equity of health resource allocation in the region accordingly. The Theil index is particularly useful when looking at both intra-regional and inter-regional disparities, providing a more granular view of where inequalities in health resource distribution arise—whether within individual regions or between them. Based on the idea of analysis of variance (ANOVA), we decompose the total Theil index into intra-regional Theil index and inter-regional Theil index. In other words, we decompose the total health resource allocation disparity in the PRD region into intra-regional health resource allocation disparity and inter-regional health resource allocation disparity. This decomposition enables a clear identification of whether the majority of disparity lies within individual regions (intra-regional) or between different regions (inter-regional), providing valuable insights for targeted policy interventions. Its calculation formulas are as follows (O'Donnell et al., 2008).

(1) Calculate the Theil index for each region

$$T_g = \sum_{i=1}^n P_{gi} \ln \frac{P_{gi}}{Y_{gi}} \quad (4.4)$$

P_{ei} refers to the proportion of the population/geographic area of city i in group g to the total, and Y_{gi} refers to the proportion of the amount of health resources of city i in group g to the total.

(2) Calculate the Theil index within each region

$$T_{\text{内}} = \sum_{g=1}^k P_g T_g \quad (4.5)$$

P_g refers to the proportion of the population/area of group g to the total.

(3) Calculate the Theil index across regions

$$T_{\text{间}} = \sum_{g=1}^k P_g \ln \frac{P_g}{Y_g} \quad (4.6)$$

Y_g refers to the proportion of the amount of health resources in group g to the total.

The Theil index measures the contribution of the resource allocation disparity across regions and the resource allocation disparity within regions to the total disparity respectively. To be specific, $T_{\text{total}} = T_{\text{intra}} + T_{\text{inter}}$, inter-group contribution rate = $T_{\text{inter}}/T_{\text{total}}$, and intra-group contribution rate = $T_{\text{intra}}/T_{\text{total}}$. This contribution breakdown highlights the relative importance of intra-regional versus inter-regional differences in health resource distribution and shows where improvements should be made to reduce disparities. The inter-group and intra-group contribution rates represent the sources of differences in equity in the allocation of health resources and the extent to which they are affected by the inter-group and intra-group

differences.

4.2.4 The Lorenz curve

The Lorenz curve is a curve used in economics to reflect the degree of inequality in income distribution, and it is commonly used in the field of health care to evaluate the equity of healthcare resource allocation. The Lorenz curve graphically represents the cumulative distribution of a variable (e.g., income or health resources) against the cumulative proportion of the population. When applied to healthcare resource allocation, it illustrates the extent to which the actual distribution of resources deviates from perfect equality. A perfectly equitable distribution would result in the Lorenz curve coinciding with the 45° line, indicating that each percentage of the population receives an equivalent percentage of the resources. Conversely, greater curvature away from the line of equality signifies higher levels of inequality in resource distribution (Gastwirth, 1972). Such visualization not only allows for an intuitive comparison between ideal and actual distributions, but also facilitates the identification of subtle patterns of inequity that might not be captured through numerical indicators alone. In health services research, this graphical interpretation can serve as an effective complement to quantitative measures, enabling policymakers and scholars to assess both the magnitude and the direction of inequality in a more comprehensive manner.

In this research, we take the number of healthcare institutions, the number of beds in healthcare institutions, and the cumulative percentage of the number of healthcare personnel in Guangdong Province as the vertical coordinate, and population and the cumulative percentage of per capita disposable income as the horizontal coordinate, to construct a coordinate system, and draws the Lorenz curve of the healthcare human resource allocation according to the population and the per capita disposable income. By incorporating multiple dimensions of healthcare resources into the construction of Lorenz curves, the analysis gains greater robustness and reflects the complexity of health system capacity. For instance, institutions represent the physical infrastructure of service delivery, beds indicate the treatment capacity available to patients, and personnel capture the human capital that is essential for the functioning of the system. The degree of equity of healthcare human resource allocation can be judged based on the degree of bending of the curve (O'Donnell et al., 2008). In practical terms, the Gini coefficient—a numerical measure derived from the Lorenz curve—quantifies the degree of inequality, ranging from 0 (perfect equality) to 1 (perfect inequality). However, the visual representation of the Lorenz curve remains a powerful tool for identifying disparities

across different regions or population subgroups. By comparing Lorenz curves constructed for different types of healthcare resources (e.g., beds, personnel, institutions), researchers can identify which aspects of resource allocation are most inequitable and prioritize policy interventions accordingly. Moreover, the comparison of Lorenz curves across resource categories helps highlight whether inequities are concentrated in infrastructure, service capacity, or workforce distribution. This layered perspective enables a more nuanced policy response, as it clarifies which type of resource imbalance contributes most significantly to the overall inequity. In turn, this can guide targeted interventions that enhance both the efficiency and fairness of healthcare delivery.

4.2.5 Fixed effects regression model

With reference to the research carried out by Nie et al. (2010) on the relationship between financial expenditure and healthcare resource allocation, this study constructs the regression model through the fixed effects method. The model takes the mortality rate of residents in different regions of Guangdong Province as the explained variable and the healthcare resource allocation indicator as the explanatory variable, and other factors affecting residents' health are controlled. All data are obtained from the Guangdong Statistical Yearbook and statistical yearbooks of various cities in Guangdong (Wang & Song, 2012). The model formula is as follows.

$$\text{Health}_{it} = \beta_0 + X_{it}\beta_1 + x_{it}\beta_2 + V_i + U_t \quad (4.7)$$

Health_{it} represents the health level of residents in province i in year t , and X_{it} refers to the indicators representing the level of urban-rural differences in the allocation of healthcare resources in province i in year t . x_{it} refers to other control variables, and V_i and U_t represent region fixed effects and time fixed effects respectively. The region-fixed effects control for all time-invariant, unobserved characteristics specific to each prefectural city (e.g., geographic features, historical legacies, and cultural factors that influence health outcomes but are constant over the study period). Simultaneously, the time-fixed effects account for common temporal shocks or trends affecting all regions in a given year (e.g., province-wide policy changes, macroeconomic fluctuations, or pandemics). This dual control mechanism helps to isolate the net effect of the explanatory variables on the health outcome by eliminating biases from unobserved heterogeneity across entities and over time. This methodological choice ensures that the estimated coefficients are not confounded by region-specific or time-specific factors that remain constant throughout the study period. Consequently, the fixed effects regression model provides a more reliable and internally valid framework for examining how healthcare

resource allocation impacts residents' health outcomes in Guangdong Province.

(1) Explained variables

The mortality rate of residents in different regions of Guangdong Province is chosen as the explained variable. Mortality rate is a common macro-indicator used to measure the health status of the population, and it has the advantages of high data availability and extensive coverage. Although mortality rate cannot fully reflect all dimensions of health (such as quality of life), it is effective in capturing health disparities between regions. According to Yang and Liu (2016), mortality rate is an important indicator to assess the health status of a region, and is particularly suitable for macro analysis. Furthermore, the use of mortality rate as the dependent variable is justified by its comparability across regions and over time, which enhances the consistency of the analysis. Mortality data are generally less subject to measurement error compared with other health indicators, making them a robust choice for longitudinal and regional studies.

(2) Explanatory variables

Due to the fact that there are many missing data on healthcare resources at the municipal level in Guangdong, it is difficult to fully measure the Theil index in different regions of Guangdong. The indicators used in the empirical regression on the healthcare resource allocation disparity in different regions of Guangdong Province mainly refer to the research of (Ge & Zhang, 2010), who analyzed the healthcare resource allocation gap in different regions of Guangdong Province through the status of healthcare resources in different regions of Guangdong. In this research, the number of healthcare workers per 1,000 people in the city is chosen as a measure of the soft power of healthcare resources, and the number of hospital beds per 1,000 people is chosen as a measure of the hard power of healthcare resources. This dichotomous approach to measuring resource allocation allows for a nuanced analysis. The “soft power” indicator (healthcare workers per 1,000 people) captures the human capital and expertise available for service delivery, which is often a critical constraint in healthcare quality. Conversely, the “hard power” indicator (hospital beds per 1,000 people) represents the infrastructural and capital investment in the healthcare system. Analyzing these two dimensions separately can reveal whether disparities in health outcomes are driven more by a shortage of human resources, physical infrastructure, or a combination of both. By distinguishing between these two categories, the model captures not only the overall adequacy of healthcare resources but also the relative contribution of human and physical capital to health outcomes. This separation is particularly important in the context of Guangdong, where rapid economic

development and demographic changes may differentially influence the supply of healthcare personnel and the expansion of medical infrastructure.

(3) Control variables

Considering the influence of other variables on the health disparity of residents in different regions of Guangdong Province, the following variables are controlled. The selection of these control variables is grounded in the Grossman model of health production and previous empirical literature, which posit that health outcomes are determined by a confluence of socioeconomic, demographic, and policy factors beyond the immediate availability of healthcare resources. Omitting these confounding variables could lead to biased estimates of the relationship between resource allocation and mortality.

① The aging rate, namely, the proportion of elderly people over 65 years old. With the increase of age, the level of people's physical health will be greatly reduced, and the percentage of the elderly population in each region also affects the overall level of health in that region (Li & Li, 2014);

The urbanization rate, namely, the proportion of urban population to the total population. On the one hand, urbanization enables the mountainous areas to get access to public resources in cities, including better medical services and medical information (Rosenzweig & Schultz, 1982); however, on the other hand, urbanization can bring about many environmental problems, such as traffic congestion, and air pollution, which can result in worsening health conditions;

The population density, namely, the ratio of total population to total area. High population density may increase pressure on public resources and affect health levels (Zhao, 2006);

The per capita disposable income, which reflects the economic level of the region. According to Wang and Chang (2007), Research suggests that economic indicators affecting residents' health can be expressed in terms of per capita disposable income, and increase of per capita disposable income is another indication that the residents of the region have higher economic power, which in turn is a positive factor affecting health levels;

The government healthcare expenditure, namely, the proportion of the local government expenditure on health care to the total annual expenditure. The government's healthcare expenditure directly reflects the development of the healthcare industry in the region, and generally speaking, the greater the government's investment in health care, the more abundant the public health resources, and the greater the positive impact on the health of the residents. Taken together, the inclusion of these control variables helps to minimize omitted variable bias and strengthens the credibility of the regression results. By accounting for demographic, socioeconomic, and policy-related determinants of health, the model is better positioned to

isolate the specific effect of healthcare resource allocation on mortality, thereby enhancing the robustness of the empirical findings.

4.2.6 DEA model analysis

Given that this study takes 21 prefecture-level cities in Guangdong Province as decision-making units, it involves a small sample size with multiple inputs and outputs in regional efficiency comparisons. Data Envelopment Analysis (DEA), as a non-parametric method, does not require the specification of a production function form or assumptions about the distribution of error terms, making it more suitable for this type of small-sample, multi-input–multi-output cross-regional efficiency analysis.

(1) Input indicators

This research analyzes the changes in the efficiency of healthcare expenditure of municipal governments in Guangdong Province from the perspective of the indicators of government expenditure on health and per capita disposable income. The selection of these input variables aligns with the DEA framework, which emphasizes capturing both supply-side fiscal commitments and demand-side economic capacity. Government health expenditure reflects deliberate budgetary allocations for medical infrastructure development, personnel training, and public health initiatives, while per capita disposable income serves as a proxy for regional healthcare purchasing power and latent service demand. This dual-input approach enables holistic assessment of resource mobilization efficiency across administrative jurisdictions. This choice of inputs also reflects the dual role of governments and households in shaping healthcare outcomes. On one hand, government health expenditure embodies the institutional commitment to expanding access and improving quality; on the other hand, per capita disposable income reflects the population's ability to utilize and benefit from such resources. The interplay of these two dimensions provides a more nuanced picture of how fiscal and socioeconomic factors jointly determine healthcare efficiency.

(2) Output indicators

The output indicators are designed to capture the tangible results and service capacity generated by the healthcare system. These indicators quantify the availability and density of key healthcare resources that are ultimately produced, at least in part, by the financial and socioeconomic inputs. In this context, outputs function as concrete manifestations of healthcare system capacity, translating abstract fiscal investments and income levels into measurable service availability. By focusing on both the scale and density of resources, the analysis ensures that differences in population size across municipalities do not obscure the underlying

disparities in healthcare provision. A fundamental premise of the DEA model is that higher efficiency is achieved when a DMU generates a greater level of these outputs from a given level of inputs, or conversely, uses fewer inputs to achieve a given output level. The selected outputs encompass both human and physical capital dimensions of healthcare provision. The output indicators are selected from the health resource indicators. The health resource indicators include the number of healthcare institutions per 1,000 population, the number of health workers per 1,000 population, the number of health technicians per 1,000 population, the number of practicing (assistant) physicians per 1,000 population, and the number of beds in healthcare institutions per 1,000 population, and these indicators represent the capability of healthcare institutions to provide healthcare resources. Together, these indicators not only capture the absolute volume of resources but also reflect the balance between human expertise and material infrastructure. This comprehensive selection enables the DEA model to evaluate efficiency from multiple dimensions, revealing whether observed differences are due to variations in staffing, institutional coverage, or physical capacity. Such an approach enhances the interpretability of the efficiency scores and provides a solid empirical foundation for subsequent policy analysis.

4.2.7 Weighting of healthcare resource allocation in Guangdong Province based on the entropy weight method

To provide a more comprehensive assessment of the allocation of medical resources in Guangdong Province, this study further constructs a composite index of medical resource allocation based on the analysis of individual indicators. This composite index is developed from three dimensions—institutional resources, bed resources, and human resources. Specifically, five indicators are selected: the number of medical institutions per 1,000 population, the number of beds in medical institutions per 1,000 population, the number of health technical personnel per 1,000 population, the number of licensed (assistant) physicians per 1,000 population, and the number of health personnel per 1,000 population. The selection of these indicators is based on the following criteria. First, they comprehensively reflect the core connotation of medical resource allocation, covering both material and human resources. Second, they possess strong representativeness and are capable of capturing interregional differences in medical resource allocation. Third, the data sources are consistent and continuous, ensuring comparability across the 21 prefecture-level cities in Guangdong Province from 2011 to 2020, both temporally and spatially. Fourth, redundancy among indicators is minimized to enhance the robustness of the composite evaluation results. In terms of weight determination,

this study employs the entropy weight method to assign objective weights. This method evaluates the information contribution of each indicator based on the degree of variation in the sample data: the greater the variability of an indicator, the stronger its ability to distinguish regional differences, and thus the higher the weight assigned. Through data standardization, entropy calculation, and weight estimation, a composite index of medical resource allocation in Guangdong Province is ultimately constructed, thereby improving the explanatory power regarding the overall level and structural differences of regional medical resources.

The entropy weight method is an objective weighting method. This technique operationalizes Shannon's information entropy principle to quantify the informational utility of evaluation metrics. By measuring the disorder degree within indicator data series, it objectively determines each variable's relative importance without subjective bias. According to the dispersion of the data of each indicator, the information entropy is used to calculate the entropy weight of each indicator, and then certain corrections are made on the entropy weight according to each indicator, so as to get more objective weights of the indicators. The entropy value can be used to determine the degree of dispersion of a certain indicator. The smaller the information entropy value, the greater the degree of dispersion of the indicator (indicating that the greater the degree of variation of the indicator value, the greater the amount of information will be provided), and the greater the impact of the indicator on the comprehensive evaluation (namely, the weight). This mathematical property ensures that indicators exhibiting greater regional heterogeneity automatically receive higher weighting coefficients than relatively stable metrics. Consequently, the entropy-weighted aggregation inherently prioritizes variables that best discriminate between Guangdong's 21 prefecture-level cities. In this way, the entropy weight method avoids arbitrary judgment in assigning importance to indicators, ensuring that the evaluation framework remains transparent and reproducible. It also provides a consistent mathematical basis for comparing regions with markedly different economic and demographic structures, which is particularly relevant in Guangdong given the pronounced contrasts between its coastal and inland cities.

In this research, the entropy weight method is used to calculate the weight of the indicators of each evaluation object in Guangdong Province. TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is used to rank the degree of proximity of each evaluation object to the ideal target, and then the advantages and disadvantages of healthcare resource allocation are evaluated accordingly. The stepwise application of the method begins with normalizing the raw data to eliminate dimensional inconsistencies across variables, followed by the calculation of entropy values that reflect the inherent information content of each indicator. This procedural

rigor strengthens the reliability of the derived weights and minimizes distortions that may arise from heterogeneous units of measurement. The formula is as follows.

$$H(x) = - \sum_{i=1}^n p(x_i) \log(p(x_i)) \quad (4.8)$$

The indicators of healthcare resource allocation efficiency and their directions are shown as per Supplemental Table a.4

The entropy weight method can determine the weight value by the magnitude of variation of the evaluation indicator, thus avoiding the influence of subjective factors on the results. By relying on the degree of variability within the dataset, the entropy weight method not only produces objective weights but also enhances the interpretability of the evaluation results. Indicators with high variability naturally gain prominence in shaping the composite score, thereby highlighting the dimensions of healthcare resource allocation where regional disparities are most pronounced. This feature provides valuable guidance for policymakers seeking to identify priority areas for intervention.

4.2.8 Difference analysis of healthcare resource allocation based on literature content analysis method

Literature content analysis is a kind of bibliometric method, which pays more attention to digging the in-depth information of the sample content. This methodological approach systematically transforms qualitative textual data into quantitative evidence through rigorous codification protocols, enabling objective identification of latent patterns across heterogeneous research outputs. Its application proves particularly valuable for synthesizing policy recommendations from fragmented academic discourse. It is a kind of research method that gives equal importance to both “quality” and “quantity”. This research adopts the method of literature content analysis, and constructs an analytical framework from the three aspects of healthcare resource evaluation method, recommended measures for healthcare resource allocation and healthcare resource change trend. The MAXqda2020 is used to enter the text of the literature based on the purposive sampling, and text encoding analysis is performed according to the analytical framework. Problems occurring in the healthcare resource allocation are analyzed through an in-depth understanding of the differences in the healthcare resource allocation between Guangdong and other provinces or municipalities, which offers constructive suggestions for the improvement of the health level of urban and rural residents in China. This method also facilitates the systematic integration of fragmented findings across studies,

transforming dispersed qualitative insights into coherent empirical evidence. By structuring unstandardized textual data into a codified analytical framework, the reliability and comparability of results are enhanced, ensuring that the conclusions drawn are both evidence-based and replicable.

4.2.8.1 Framework construction

4.2.8.1.1 Health resource evaluation method

The assessment of equity in health resource allocation necessitates a rigorous methodological foundation grounded in welfare economics and social justice theory. These axiomatic principles provide a normative framework to ensure that the evaluation is not merely descriptive but also conforms to established notions of fairness and distributive justice. Adherence to these principles allows for a robust and theoretically sound comparison of resource distribution across different regions and population subgroups, moving beyond simple measures of quantity to assess the qualitative aspect of allocation fairness. When evaluating equity, several axiomatic principles should be followed. 1. The principle of irrelevance of income owners; 2. the principle of relative income; 3. the Pigou-Dalton transfer principle; 4. the principle of unchanged scale and size; and 5. the principle of decomposability. The principle of decomposability is particularly salient for this study, as it allows for the disaggregation of overall inequality into constituent parts, such as intra-regional and inter-regional disparities. This is crucial for a province like Guangdong with significant internal diversity, as it enables policymakers to identify whether inequity stems primarily from differences between the Pearl River Delta and other regions or from inequalities within each region itself. This precise identification is a prerequisite for formulating targeted and effective policy interventions. In this research, we mainly take health resource evaluation methods and health resource evaluation indexes as the coding criteria, encode the keywords of the retrieved literature, explore the evaluation criteria and evaluation indexes of health resource equity in Chinese studies, and discuss the application of evaluation methods for health resource equity. We seek more accurate and reasonable health resource evaluation indicators and evaluation methods to avoid the errors and limitations caused by using a single indicator or a single method, so as to make a more comprehensive evaluation of China's health resources. At the same time, it will provide a scientific basis for the regional health planning of the government departments and promote the practice of health resources equity evaluation standards. Moreover, the coding process allows for the identification of recurring themes and methodological preferences in the literature, highlighting both the strengths and the blind spots of existing scholarship. Such insights not only consolidate current

knowledge but also help delineate directions for future research by exposing areas where evaluation approaches remain underdeveloped or inconsistently applied.

4.2.8.1.2 Trend of changes in health resource allocation

In the preliminary literature research, it is found that most research on health resource allocation mainly focuses on the comparative analysis of health resources within provinces and municipalities, with little in-depth discussion on the trend in changes of resource allocation in urban and rural primary healthcare institutions over the past decade (Li, 2018; Liang et al., 2010; Niu et al., 2018). In China, the new medical reform has been launched for ten years. After 2012, with the support of national policies and funding, what are the changing trends of health resource allocation in primary healthcare organizations? Has the unreasonable pattern of health resource allocation in urban and rural areas been improved? What problems still exist? How should the problems be adjusted? Answering these questions is critical for evaluating the effectiveness of a decade of health system reform. A longitudinal analysis of resource trends can reveal whether policy goals have been met, identify persistent or emerging structural bottlenecks, and illuminate the evolving relationship between resource inputs and health system performance. This analysis moves beyond a static snapshot to provide a dynamic understanding of the system's evolution, offering insights into the long-term impacts of policy investments and market forces. In this research, we will analyze the trend of changes in the allocation of health resources in terms of software and hardware, understand the trend of changes in various provinces and municipalities, and propose suggestions and countermeasures to improve the service capacity of health resources in Guangdong Province with reference to other provinces.

4.2.8.1.3 Recommendations for health resource improvement based on policy instruments

Policy instrument is an important path of public policy research, and it is the development and deepening of policy process analysis at the level of instrumental rationality. This typology moves beyond viewing policy as a monolithic intervention and instead dissects it into actionable components. Analyzing policies through the lens of instruments allows for a systematic understanding of the government's tactical approach to governance—whether it focuses on direct provision (supply), creating conducive conditions (environment), or stimulating market activity (demand). The strategic combination of these instruments is essential for creating a coherent and effective policy mix that addresses complex multi-faceted challenges like health resource allocation, where no single instrument is sufficient. The Public Policy Theory holds that when policy subjects formulate and implement policies, they must organically integrate the policies based on the objective relationship between them, so as to form a policy synergy, achieve complementarity in function, and give full play to the desired policy effect. In the

literature on health resource allocation, researchers have made certain recommendations and countermeasures after evaluating the allocation of health resources in each province and municipality. Based on the ideas of Rothwell and Zegveld (1985), we categorize the basic policy instruments into three types: supply-based, environment-based, and demand-based instruments.

Supply-based policy instruments

Supply-based policy instruments are often manifested as the government's driving force for the implementation of health resource allocation equity policies, which means promoting the equitable development health resource allocation in China through the government's direct expansion of supply through the support of human resources, information, technology, and capital (Zhu et al., 2023). Supply-based policy instruments can be subdivided into six major aspects: scientific and technological support, infrastructure, public services, information services, talent training, and capital investment (Y. Zhang et al., 2018).

Environment-based policy instruments

Environment-based policy instruments are often manifested as the influence of policy on public health services, which specifically refers to the provision of a favorable policy environment for the equity of health resource allocation in China by the government through the financial, taxation, laws and regulations and other policies to influence the environmental factors of public health services. The environment-based policy instruments can be subdivided into five aspects: tax incentives, service standards, health insurance support, regulatory control, and financial services (Zhu et al., 2023).

Demand-based policy instruments

Demand-based policy instruments refer to the reduction of market uncertainty by the government through measures such as procurement and trade control to actively develop and adjust the rationality of health resource allocation in China, so as to promote the government departments to actively develop and utilize the potential of the public health services (Yang et al., 2017), and provide the public with convenient and accessible public health services. These instruments operate by reducing market uncertainty and stimulating activity on the demand side, thereby leveraging non-governmental forces to achieve public policy objectives. Rather than directly providing resources or shaping the environment, demand-side instruments empower citizens as consumers and encourage private sector innovation and investment in service delivery. This approach can often lead to more efficient, responsive, and sustainable solutions than purely government-led supply-side interventions. The interplay among supply-based, environment-based, and demand-based instruments is therefore central to policy design. A fragmented or unbalanced reliance on one type of instrument may undermine the effectiveness

of reform initiatives, whereas a coordinated policy mix ensures that structural, institutional, and market dimensions are simultaneously addressed. This holistic perspective underscores the necessity of designing resource allocation policies as integrated packages rather than isolated measures. The demand-based policy instruments can be further categorized into five aspects: government purchase, demonstration pilot, service outsourcing, cooperative model, and market shaping.

The ways in which the three policies work in conjunction with each other and the two-dimensional analytical framework are as follows, as shown in Figures 4.1 and 4.2 (Zhu et al., 2023).

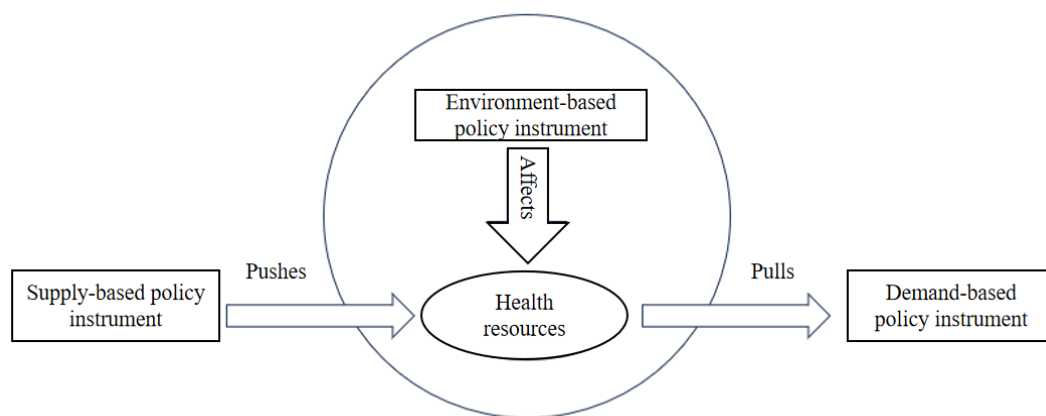


Figure 4.1 Integrated mechanism of action for the three policy instruments

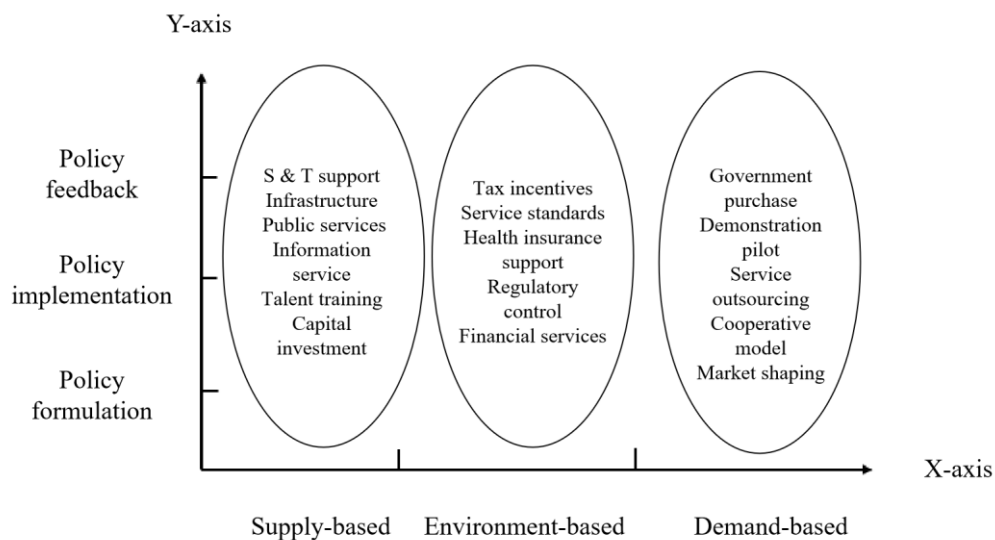


Figure 4.2 Two-dimensional analysis framework for health resource policies

4.2.8.2 Literature coding

There are three frameworks in this research based on the analysis categories of the literature, namely, methods of evaluation, trends of change, and suggestions for improvement, and different codes and subcodes are established under each framework, as shown in Supplemental Table a.5, and the unit of analysis is the text of the relevant literature on health resource allocation. The 18 screened studies are coded according to “literature name - specific content/method”, and finally the coding tables for the content analysis of the literature on health care services from the perspectives of methods of evaluation, trends of change, and suggestions for improvement are formed. As illustrated in Figure 4.3, which shows the final coding results of the literature content through MAXQDA.

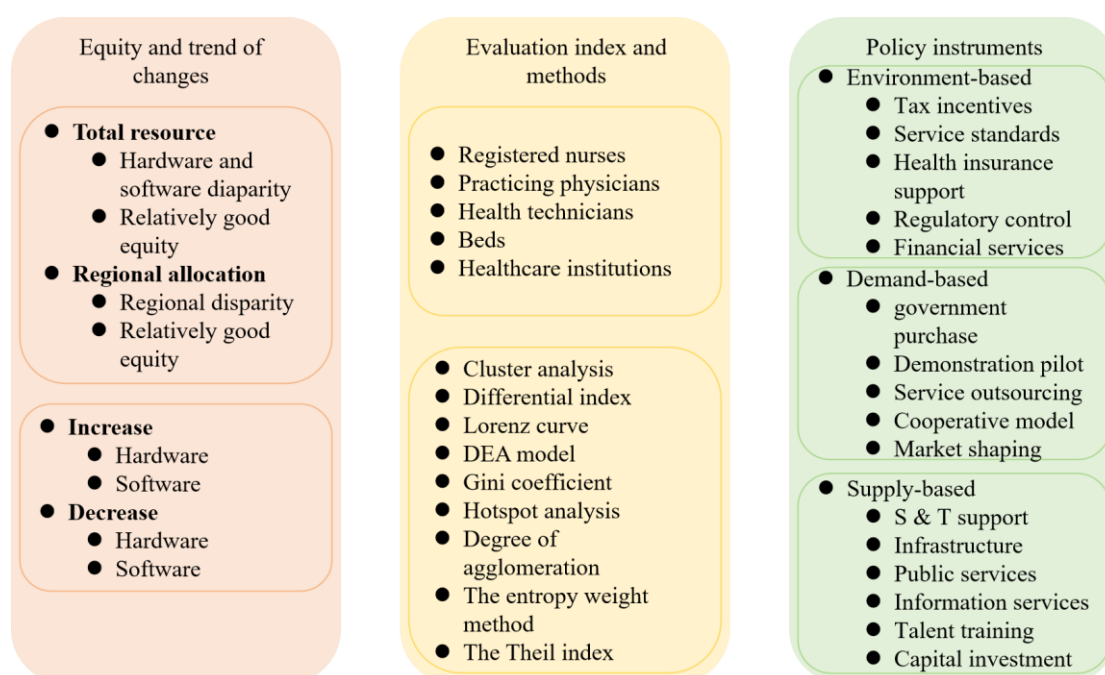


Figure 4.3 The final coding results of the literature content through MAXQDA

4.2.9 Analysis of the current situation of regional allocation of health resources in Guangdong Province based on qualitative interviews

To enhance the transparency and reproducibility of the qualitative interview process, this study follows a structured procedure consisting of: clarification of research objectives, selection of interview participants, design of the interview protocol, pilot testing and revision, implementation of formal interviews, data organization and analysis, and quality control. First, focusing on the formation mechanisms of disparities in medical resource allocation in Guangdong Province and their impacts on residents' health, the interviews center on the current status of resource allocation, major issues, underlying causes, and potential optimization

pathways. Second, in accordance with the research objectives, three categories of key informants are selected: health administrative officials, managers of medical institutions, and clinical and public health professionals, representing the levels of policy-making, institutional operation, and frontline service delivery, respectively. Third, a semi-structured interview guide is developed prior to the formal interviews, and refined through pilot interviews to improve question wording, sequencing, and feasibility. During the formal interview stage, different methods are employed based on the characteristics of the participants, including one-on-one interviews, focus group discussions, and critical incident interviews, with each session lasting approximately 60–90 minutes. Throughout the interviews, audio recordings and detailed notes are taken simultaneously, and probing and clarification techniques are used to ensure data completeness. After the interviews, all materials are transcribed verbatim. Member checking and peer debriefing are conducted to enhance the credibility of the findings. Subsequently, the textual data are subjected to inductive analysis, including coding and theme extraction. The qualitative findings are then triangulated with results from literature review and statistical analysis to explain the formation mechanisms of regional disparities in medical resource allocation in Guangdong Province and their impacts on residents' health.

4.2.9.1 Interviewee

Interviewees of this study include health administrative personnel, healthcare institution administrators, and clinical staff at different levels to ensure that the findings are comprehensive and representative. The selection of these three distinct stakeholder groups is designed to capture a multi-level perspective on the healthcare system, from macro-level policy formulation and strategic planning to meso-level institutional management and micro-level clinical service delivery. These three categories of personnel were carefully chosen not only for their expertise but also for their significant roles in shaping and implementing health policies at various levels of the healthcare system. The importance of understanding the relationship between regional health policy and the realities of healthcare provision at the institutional and clinical levels cannot be overstated. By engaging with stakeholders from diverse levels of the healthcare system, this study seeks to gather insights that reflect both strategic-level decision-making and day-to-day operational challenges. This depth of perspective is crucial for understanding how resources are allocated, how policies are executed, and how these factors ultimately influence health outcomes for the population. This triangulation of data sources is essential for constructing a holistic and nuanced understanding of the complex mechanisms linking resource allocation to health outcomes, as each group possesses unique insights and experiences shaped

by their specific roles and responsibilities within the healthcare hierarchy. To be specific, the following three categories of personnel are included.

(1) Health administrative personnel: this category of interviewees include leaders in charge of the Planning Division of the Guangdong Provincial Health Commission and the Health Bureaus of each city, totaling 16 people. Purposive sampling is used to select administrative personnel who are familiar with regional healthcare policies and resource allocation as the interviewees to ensure that they are able to provide a macro perspective on resource allocation and policy implementation. Their strategic positions provide invaluable insights into the rationale behind regional health planning, the mechanics of fiscal transfer payments, the challenges of inter-departmental coordination, and the implementation gaps between provincial policies and local realities.

(2) Healthcare institution administrators: this category of interviewees include 8 directors of tertiary hospitals, 16 deputy directors in charge of daily operation of secondary hospitals, and 24 heads of primary healthcare institutions. Stratified sampling method is used to stratify the healthcare institutions according to their levels (tertiary hospitals, secondary hospitals, and primary healthcare institutions), and then a certain number of administrators are randomly selected from each level as the interviewees, so as to reflect the current situation of resource allocation and management in different levels of healthcare institutions. To ensure that the perspectives gathered from these administrators are as varied and representative as possible, the sampling also considers institutional differences in terms of geographic location, size, and patient demographics. This broadens the scope of the study, allowing for a nuanced understanding of how different healthcare settings experience and manage the allocation of resources. For example, administrators from rural primary healthcare centers may face distinct challenges compared to those in urban tertiary hospitals, such as a higher burden of basic service provision and a more limited pool of medical professionals. These distinctions are crucial for understanding the broader implications of healthcare policies on resource allocation. Administrators from tertiary hospitals can speak to the challenges of managing large, specialized centers and their role in regional referral networks. Those from secondary hospitals often highlight issues of capacity and the pressure of handling a significant patient load with constrained resources. Heads of primary healthcare institutions provide critical ground-level perspectives on grassroots service delivery, resource scarcity, and the implementation of gatekeeping and hierarchical diagnosis systems.

(3) Clinical staff: this category of interviewees include obstetricians and gynecologists, pediatricians, imaging physicians and public health personnel, totaling 96 people. Convenience

sampling method is used to select representative and easily accessible medical staff as interviewees to ensure that views on resource allocation and accessibility of medical services can be shared from a practical perspective. The selection of specialties—obstetrics/gynecology, pediatrics, imaging, and public health—is deliberate. These clinical specialties were chosen not only for their current demand but also for their critical role in maintaining public health, especially given the diverse health challenges in Guangdong Province. Obstetrics and gynecology, for instance, is essential for maternal and child health, which remains a priority in health policies, while pediatrics addresses the long-term development and well-being of children, a vulnerable population. Imaging, as a diagnostic tool, has grown increasingly important in providing timely and accurate diagnoses, yet it often faces challenges in equitable distribution, creating regional disparities in access. Public health personnel, who focus on disease prevention, vaccination programs, and health education, are vital to managing the broader public health landscape, yet their work often goes underfunded compared to more acute care services. The inclusion of these specialties ensures that the study captures a comprehensive range of healthcare services, both curative and preventive, and addresses the allocation challenges within these domains. The first two are high-demand clinical services often facing resource shortages; imaging represents a crucial diagnostic resource whose uneven distribution can create significant bottlenecks in care pathways; and public health personnel offer a perspective on population-level prevention and health management, which is often under-resourced compared to curative services. Their frontline experiences provide empirical evidence on how allocation disparities directly impact clinical workflows, patient access, treatment quality, and ultimately, health outcomes.

Consequently, the purposive sampling of administrative personnel ensures depth of policy insight, the stratified sampling of institution administrators guarantees breadth across system levels, and the convenience sampling of clinical staff, while less random, secures rich, operational detail from key service domains. While the sampling approach for clinical staff prioritizes accessibility and richness of data over statistical representativeness, the combination of all three methods strengthens the validity of the findings through methodological triangulation. Through the above sampling method, this study ensures the diversity and representativeness of the interviewees, providing a solid foundation for an in-depth analysis of healthcare resource allocation and residents' health status in Guangdong Province.

4.2.9.2 Interview modality

Face-to-face semi-structured in-depth interview is adopted, and the length of the interview is

controlled at 60-90 minutes. The semi-structured format provides a crucial balance between consistency and flexibility. The semi-structured format was chosen specifically to provide the interviewees with the space to share their personal narratives and unique insights, while still ensuring that all key themes were addressed in a comparable manner across all participants. This method allows for the exploration of unanticipated topics and ensures that the researcher can probe deeper into areas of particular relevance as they arise during the conversation, making it a dynamic and adaptable approach to qualitative research. Furthermore, the format promotes a more conversational flow, which can help ease participants into discussing complex or sensitive issues by building rapport and trust between the interviewer and the interviewee. By combining structure with flexibility, this modality fosters richer and more nuanced data collection. A standardized interview protocol, comprising open-ended primary questions and pre-defined probes, ensures that core topics are systematically covered across all interviews, facilitating comparative analysis. Simultaneously, it allows the interviewer the necessary flexibility to diverge from the guide to pursue unanticipated yet relevant themes that emerge from the participants' narratives, thereby capturing the depth and complexity of their experiences and perspectives. Pre-testing is conducted before the interviews to optimize the question design. The pre-testing phase was essential not only to evaluate the clarity and flow of the interview questions but also to assess whether the questions resonated with the participants' own experiences and perspectives. During this phase, the researcher observed the participants' reactions to specific questions, paying close attention to any difficulties they encountered or any areas where further clarification might be needed. These observations provided invaluable insights into how the questions might be perceived or interpreted differently by the target sample. This iterative refinement process, which involved adjusting the phrasing and ensuring logical consistency in question sequencing, contributed significantly to the overall quality of the interview protocol and helped mitigate potential biases in the data collection process. This pre-testing phase was conducted with a small sample of individuals possessing backgrounds similar to the target interviewees. It served to assess the clarity, comprehensibility, and logical flow of the questions, identify any potential leading or ambiguous wording, and estimate the approximate time required for completion. Feedback from this phase was used to refine the phrasing of questions, adjust the sequence of topics, and finalize the interview protocol to enhance its validity and reliability before deployment in the formal study. The contents are recorded in detail during the interviews, and vague information is clarified through follow-up questions to ensure the reliability and accuracy of the data. Follow-up questions, often posed in the form of prompts or clarifications, were integral in eliciting deeper reflections from the

participants. These questions were specifically designed to encourage further elaboration on points of interest, as well as to address any ambiguities or inconsistencies that arose during the interviews. This step not only ensured that the data gathered was comprehensive but also that the participants' responses were fully understood within the context of the research objectives. Additionally, the researcher remained attuned to non-verbal cues such as body language and facial expressions, which often provided important contextual information and emotional undertones that were crucial to interpreting the participants' verbal responses accurately. This involved comprehensive audio recording with the prior consent of all participants, supplemented by real-time field notes taken by the researcher to document key points, non-verbal cues, and initial observational insights. The audio recordings were subsequently transcribed verbatim to create a complete textual dataset for rigorous analysis. The meticulous documentation process ensures the permanence and verifiability of the raw data, which is a foundational requirement for qualitative research integrity. Additionally, the process of transcribing the audio recordings was carried out with great attention to detail, ensuring that every nuance of the conversation, including pauses, intonations, and emphases, was accurately captured. This level of transcription rigor allowed the researcher to fully immerse themselves in the interview content and facilitated a deeper understanding of the participants' viewpoints. The complete and verbatim transcriptions were essential for performing a robust and thorough analysis, which required not only content but also an understanding of the underlying meanings embedded in the narratives. This comprehensive approach to data documentation set the foundation for a rigorous, systematic analysis process, ensuring the credibility and reliability of the findings. Techniques such as member checking and peer debriefing among the research team were employed to enhance the trustworthiness of the data interpretation. This iterative process of immediate clarification during the interview and subsequent validation steps minimizes misinterpretation, strengthens the factual accuracy of the accounts, and ultimately.

4.2.9.3 Interview method

The interview is designed in a multi-level semi-structured manner covering policy makers, institution administrators and clinical staff. This tiered approach is designed to elicit data that corresponds to the specific operational realities and strategic purviews of each stakeholder group. The interview protocols, while sharing a common overarching theme of exploring resource allocation and its impacts, were meticulously tailored to align with the specific knowledge, experiences, and decision-making boundaries of each category of interviewee. In terms of interview formats, differentiated approaches are adopted according to the work

characteristics and informational attributes of respondents at different levels. Specifically, in-depth one-on-one interviews are conducted with health administrative officials to obtain key insights into policy formulation and decision-making processes related to resource allocation. Focus group discussions are employed for managers of medical institutions to facilitate comparison and interaction among management experiences across different institutions. For clinical and public health professionals, the critical incident interview method is applied, focusing on the retrospective analysis of typical cases encountered in practice, thereby providing a more concrete reflection of resource allocation issues in frontline service delivery. This ensures that the questions are relevant, appropriate, and capable of generating the deepest possible insights from each participant.

(1) Administrative decision-making level: One-on-one interviews (60-90 minutes each) are conducted with a total of 16 interviewees, including leaders from the Planning Division of the Guangdong Provincial Health Commission, and health bureaus of eight sample cities in four regions of the Pearl River Delta (Guangzhou and Dongguan), eastern Guangdong (Shantou and Meizhou), western Guangdong (Zhanjiang and Yangjiang), and northern Guangdong (Shaoguan and Qingyuan). The interview focuses on the basis for the compilation of the regional health plan, the mechanism of financial transfers, and the standard of performance assessment in resource allocation. Probing questions were designed to uncover not only the formal, documented processes but also the informal negotiations, practical constraints, and political economy considerations that ultimately shape allocation decisions. Interviewees were encouraged to reflect on the tensions between equity goals and efficiency metrics, the challenges of vertical and horizontal coordination between different levels of government, and the evidence base used to justify investment priorities in a context of fiscal scarcity. These interviews are designed to gain insights into the views of policy makers on the uneven resource allocation and its impact on health disparities of residents. The one-on-one format was deemed essential for this group to ensure confidentiality and foster candor, allowing senior officials to discuss sensitive issues of policy shortcomings and inter-regional competition without the constraints of a group setting. Interviews were conducted in the officials' offices to situate them in their natural decision-making environment, and the substantial volume of verbatim transcriptions (240,000 words) provides a rich, qualitative dataset for thematic analysis of policy narratives and implementation challenges.

(2) Institutional administration level: In the sample of 48 healthcare institutions, 8 directors of tertiary hospitals, 16 deputy directors in charge of daily operation of secondary hospitals, and 24 heads of primary healthcare institutions are selected through stratified sampling

according to institution level. Focus group discussions are conducted (with 6 people in each group) to systematically analyze the priority of equipment allocation and the main causes of brain drain. The group setting was strategically chosen for this tier to stimulate dialogue, reveal consensus, and expose divergent viewpoints among peers facing similar managerial challenges. A skilled moderator used the semi-structured guide to facilitate discussion, ensuring all participants contributed while allowing for the organic emergence of themes. The interactive nature of focus groups often leads to a form of ‘validation’ of experiences, where one administrator’s account resonates with and is elaborated upon by others, thereby strengthening the credibility of the identified issues, such as the 53 key contradictory cases documenting tensions between policy mandates and operational realities. These discussions help to reveal the coping strategies of institutional administrators in the context of uneven resource allocation and their impact on residents’ health disparities.

(3) Clinical level: For departments with prominent resource shortages, special interviews are conducted with a total of 96 physicians in obstetrics and gynecology, pediatrics, and imaging, as well as public health personnel. 28 referral cases due to insufficient equipment and 12 types of outpatient services canceled due to manpower shortages over the last 3 years are documented through the critical incident method. These interviews help to understand the challenges of frontline clinical staff working in the context of uneven resource allocation and its impact on patient health. By asking clinicians to recall and detail particular instances of referrals or service cancellations, the study gathers robust empirical evidence of how macro-level allocation disparities directly disrupt clinical pathways and compromise patient care. This method minimizes recall bias and yields powerful, illustrative case studies that quantify the human and operational impact of resource inequality at the frontline of service delivery.

4.2.9.4 Interview content

4.2.9.4.1 Interview on health administrative personnel

The interview protocol for health administrative personnel was meticulously designed to elicit in-depth insights into the macro-level planning, policy rationale, and systemic challenges shaping healthcare resource allocation in Guangdong. The questions probe three critical dimensions: the principles and practicalities of regional health planning, the mechanisms and efficacy of performance assessment systems, and the strategies for regional coordination in a complex policy environment. The following core questions guided the semi-structured interviews, aiming to uncover the decision-making processes, implementation barriers, and strategic priorities from the perspective of key policymakers.

1. Regional health planning

(1) In the formulation of regional health planning, what are the specific factors (population density, changes in disease spectrum, efficiency of utilization of existing resources) that are mainly taken into account in identifying the allocation of health resources?

(2) How do you comment on the current gap in the allocation of health resources between the PRD region and other regions? How is this gap reflected and considered in the planning? Are there any specific adjustment measures?

(3) Can you share the biggest difficulties and challenges encountered in the implementation of health planning? What measures have you taken to address them?

(4) When dynamically adjusting the allocation of health resources, how do you balance the structural contradiction between the aging population and the short-term demand for medical services from migrant workers? What priority setting or resource allocation strategies have you adopted?

2. Resource allocation performance assessment

(1) What are the main aspects of health resource allocation performance assessment criteria currently used (such as resource utilization efficiency, service accessibility, resident health improvement)? What methods are used to identify these criteria?

(2) In the assessment system, how is the impact of resource allocation on health disparities specifically quantified? Is there a correlation model for health outcome indicators (mortality rate, prevalence of chronic diseases) and resource allocation (beds per 1,000 people, number of healthcare workers)? Please provide examples.

(3) Based on the results of previous assessments, what are the most prominent problems in resource allocation (such as geographic disparities and imbalance between human and material resources)? What specific improvement measures have been taken to address these problems?

3. Regional collaborative development

(1) Under the framework of collaborative development of healthcare in the Guangdong-Hong Kong-Macao Greater Bay Area, what are the challenges faced by the existing resource allocation mechanism in adapting to the demand for cross-border healthcare services? What specific measures have been taken to address these challenges?

(2) If given an additional 10% of the health budget, which aspect would you prioritize to improve resource allocation? Why?

(3) Compared with the Yangtze River Delta region, what do you think are the unique strengths and weaknesses of Guangdong Province in its health resource allocation mechanism?

4.2.9.4.2 Interview on healthcare institution administrators

The interview protocol for healthcare institution administrators was designed to investigate operational challenges and strategic responses at the organizational level, focusing on three core dimensions critical to understanding healthcare delivery under conditions of resource disparity. First, it probes internal resource management strategies, specifically the principles guiding capital equipment investment and the retention of human capital. Second, it examines the institution's role within the broader healthcare ecosystem, particularly its relationship with and support for primary healthcare institutions. Finally, it explores the institution's interaction with external systems, navigating the complexities of medical insurance schemes and public health literacy. The following questions were formulated to elicit detailed insights into these areas, capturing the pragmatic realities of managing healthcare delivery within the constraints of the current allocation framework.

1. Equipment deployment and brain drain

(1) How do hospitals identify priority when it comes to equipment deployment? For example, what are the main considerations (such as urgency of equipment needs, cost-effectiveness, and patient flow) when purchasing large equipment such as CT/MRI?

(2) What is the situation of brain drain in the hospital in recent years? What departments (such as internal medicine and surgery) or positions witness most of the brain drain? What do you think are the main reasons for the brain drain (such as salary, working environment, career development opportunities)?

(3) What specific measures have been taken by the hospital to cope with the problem of brain drain and insufficient equipment deployment? How effective is the implementation of these measures? Can you share some successful cases?

2. Development of primary healthcare institutions

(1) What do you think are the major problems (such as lack of funds and insufficient technical support) in the standardized construction of primary healthcare institutions? Given that the hardware facilities meet the standard, how to obtain operation and maintenance funds?

(2) How do you comment on the collaborative relationship between primary healthcare institutions and higher-level hospitals? What are the major difficulties and challenges (such as information sharing and resource coordination) faced in the establishment of medical alliances? How do you think these collaboration mechanisms can be improved?

(3) What are your specific suggestions (such as promotion of service quality, improvement of patient satisfaction, and advancement of medical technology) on the enhancement of the service capacity of primary healthcare institutions?

3. Medical insurance settlement and health information literacy

(1) What practical problems (such as asymmetric information and policy differences) have hospitals encountered in terms of cross-city medical insurance settlement? How to achieve coordination between the place of insurance participation and the place of medical treatment?

(2) How do you comment on the confusion and dissatisfaction of patients in the process of medical insurance settlement? What specific measures have hospitals taken (such as strengthening of training and optimization of process) to improve patient satisfaction?

(3) What specific work has the hospital done to improve residents' health information literacy? How effective are these efforts? What other support and cooperation do you think is needed (such as government policies and community cooperation)?

4.2.9.4.3 Interview on clinical staff

The interview protocol for clinical staff was designed to capture the ground-level realities of providing healthcare within a context of resource disparity, focusing on three interconnected dimensions that directly shape daily practice and patient outcomes. First, it investigates the immediate clinical impact of resource shortages on diagnostic and treatment processes, particularly in cross-regional care scenarios. Second, it explores the interplay between technological adoption and the doctor-patient relationship, examining both the potential and the limitations of new tools in mitigating resource constraints. Finally, it seeks frontline perspectives on health policy and system design, soliciting concrete recommendations based on practical experience. The following questions aim to elucidate the operational challenges, adaptive strategies, and systemic barriers encountered by healthcare professionals at the point of service delivery.

1. Impact of resource shortage on medical treatment

(1) When receiving patients referred across regions, what typical problems in diagnosis and treatment (such as insufficient equipment, shortage of medicines and lack of specialized personnel) have you observed due to differences in resource allocation? Please specifically describe the process of handling these problems.

2. Doctor-patient relationship and technology application

(1) What specific difficulties and challenges have you encountered in the application of new technologies such as telemedicine (such as technical barriers, patient trust, and operational complexity)? To what degree do patients accept telemedicine?

(2) What specific roles do the new technologies play in improving the doctor-patient relationship? Are there any negative impacts? Please give examples.

(3) What specific aspects of support and improvement do you think are still needed to

improve the quality of medical services (such as technical training, equipment updating, and policy support)?

3. Views on policies and systems

(1) From your perspective, what are the specific deficiencies of the current health resource allocation policies and systems (such as uneven distribution of resources, insufficient funding, and inadequate implementation of policies)? How have these deficiencies affected your work?

(2) What specific suggestions do you have on improving the uneven allocation of health resources (such as increase of investment on primary healthcare institutions, optimization of the resource allocation mechanism, and strengthening of personnel training)? What specific measures do you think the government and relevant departments should take?

(3) How do you comment on the actual effect of the construction of county-level medical centers under the “100 Counties Project” in alleviating the uneven allocation of resources (such as coverage of resources, accessibility of services, and improvement of residents’ health)?

4.2.9.5 Interview Data Processing Methodology for Healthcare Resource Allocation

In this study, interviews were employed as a key qualitative research method to explore the current situation of healthcare resource allocation and its impact on residents' health in Guangdong Province. The primary aim of the interviews was to obtain firsthand information regarding the allocation of healthcare resources, the policies guiding distribution, and the practical application of these policies through in-depth discussions with experts, administrators, and frontline healthcare professionals. The interview methodology allowed the research to uncover the specific causes of uneven distribution and the real consequences of these disparities, offering insights that quantitative research could not fully capture.

The study adopted semi-structured interviews, designed to guide respondents with open-ended questions while ensuring that the discussions stayed focused on the core topics. Semi-structured interviews allow researchers to adjust follow-up questions based on responses, enabling the capture of detailed experiences and perspectives. This approach provides flexibility while maintaining consistency and systematic data collection. The interview questions were based on the study’s key objectives, including analyzing the resource allocation mechanisms, regional disparities, and the effects of resource distribution on residents' health. The questions covered a broad range of topics, such as the background of policy formulation, criteria for resource allocation, the implementation of current systems, and the specific impacts of resource distribution on health in different regions. Through these questions, the study sought to understand how different levels of government and healthcare institutions operate within the

resource allocation framework, uncovering issues in policy implementation and suggesting potential improvements.

The selection of interviewees was comprehensive, ensuring that multiple perspectives were represented. Participants included health administrative managers, healthcare institution administrators, and frontline clinical staff, providing diverse insights into the issue. Health administrators primarily provided detailed information regarding policy background, allocation standards, and decision-making processes. Healthcare institution administrators offered practical perspectives on the challenges faced during resource allocation and its execution. Clinical staff participated to reveal how resource allocation affects patient care and treatment outcomes, thus illustrating the impact of imbalanced resource distribution on healthcare quality and efficiency.

During data collection, rigorous audio recording and transcription methods were employed to ensure the accuracy and completeness of the data. Each interview was recorded to faithfully capture the respondent's words. Afterward, the transcripts were reviewed and verified with the participants to ensure the accuracy of the recorded information. To enhance data reliability, the study used a multi-round review process, ensuring that each interview record underwent careful examination. Throughout the interviews, the researchers maintained an objective, neutral stance, avoiding leading questions to ensure that the data reflected the genuine views and experiences of the respondents.

The rapport established between the researchers and the interviewees played a crucial role in facilitating data collection. The interaction enabled researchers to better understand the context and background of the issues described, fostering in-depth analysis of complex phenomena. Interviewees generally exhibited a high level of participation and willingness to share their experiences. Many participants not only provided their views on healthcare resource allocation but also shared specific experiences from their professional lives. These in-depth descriptions provided valuable qualitative data that helped to better understand the underlying mechanisms and practical effects of healthcare resource distribution.

In the later stages of the study, the transcribed interview data underwent content analysis. Content analysis is a method used to categorize and summarize key themes, patterns, and ideas from the interview texts. The researchers systematically organized the data and identified several core themes, such as the mechanisms of resource allocation, regional disparities in resources, and the impact of resource shortages. Through detailed analysis of the interview data, the researchers were able to examine the uneven distribution of healthcare resources from multiple perspectives, understand how different levels of government and healthcare

institutions responded to these disparities, and evaluate the effectiveness of the strategies employed. The content analysis not only revealed the impact of uneven resource allocation on the quality of healthcare services but also provided valuable insights for policy improvement.

Overall, the interview methodology in this study provided a deep understanding of the current state of healthcare resource allocation in Guangdong Province. By conducting multi-level and multi-perspective interviews, the researchers were able to comprehensively explore the issues and challenges surrounding healthcare resource distribution. The analysis of the interview data enriched the theoretical framework of the study and provided valuable field evidence for future policy development and improvements. Throughout the data collection and analysis process, the researchers maintained a high level of professionalism and care, ensuring the authenticity and reliability of the interview data, thus laying a solid foundation for the study.

4.2.10 Questionnaire-based analysis of healthcare resource allocation and residents' health status in Guangdong Province

4.2.10.1 Research subjects

This study takes permanent residents aged 18 years and above in Guangdong Province as the research subjects. The choice of this population is crucial as it allows the research to focus on individuals who not only have the legal right to reside in Guangdong but also contribute to the local economy, which significantly impacts healthcare needs and utilization. Furthermore, this group represents a key demographic for healthcare policy interventions and reforms aimed at improving public health outcomes. And the selection of this demographic cohort is strategically significant for several methodological and substantive reasons. Adults aged 18 and above represent the population segment most actively engaged with the healthcare system, making critical decisions regarding healthcare utilization for themselves and often for their dependents. This group, comprising both younger adults beginning their healthcare engagement and older adults with established healthcare needs, forms the backbone of the health system's patient base. Their healthcare decision-making is crucial in shaping demand for services ranging from preventative care to chronic disease management, making their experiences an essential focus for the study. Their experiences and perceptions provide the most direct and reliable insights into the accessibility, affordability, and quality of healthcare services available within their communities. Focusing on permanent residents, as opposed to a transient population, ensures that the reported health status and healthcare experiences are intrinsically linked to the long-term availability and allocation of resources within that specific region, thereby providing a

stable and meaningful basis for analyzing the impact of resource distribution. A transient population, by contrast, may introduce variability in healthcare utilization patterns due to temporary residency, such as individuals seeking medical services only while visiting or staying for a short duration. By concentrating on permanent residents, the study minimizes such externalities, ensuring that the findings are reflective of the healthcare dynamics faced by individuals who are consistently exposed to local healthcare infrastructure and policies. According to the National Bureau of Statistics, permanent residents are defined as household and non-household residents who have lived in the surveyed area for a continuous period of no less than 6 months. This specific definition ensures that individuals who may have recently moved to the area are excluded, further enhancing the stability and consistency of the dataset. The six-month minimum residency requirement is a standard demographic criterion that guarantees the selected participants have had sufficient time to engage with and form opinions about the local healthcare system, making their insights more relevant and accurate. This operational definition, aligned with national statistical standards, ensures methodological consistency and enhances the comparability of findings with other large-scale demographic and health surveys conducted in China. By including both household and non-household registered residents, the study aims to capture a more comprehensive picture of the healthcare experiences of the entire de facto population residing in Guangdong, thus improving the external validity of the research findings. In terms of regional coverage, the stratified sampling method is adopted to include the Pearl River Delta region (9 cities including Guangzhou and Shenzhen), eastern Guangdong (4 cities including Shantou and Chaozhou), western Guangdong (3 cities including Zhanjiang and Maoming), and northern Guangdong (5 cities including Shaoguan and Qingyuan), so as to ensure a balanced spatial distribution of the samples and representativeness of the regional characteristics. This stratified approach ensures that the study captures the diversity of healthcare experiences across Guangdong's distinct geographic regions. By including both highly urbanized areas with advanced healthcare systems and more rural regions where healthcare access may be limited, the study provides a holistic understanding of how geographical factors influence healthcare experiences and perceptions.

4.2.10.2 Sampling methods and sample size estimation

The multi-stage stratified probability proportional sampling method is adopted, and the specific implementation steps are as follows.

(1) First-stage sampling: Based on the population census data of Guangdong Province, the 21 prefectural-level cities are divided into four regions according to the core indicators such as

economic development, urbanization rate, and population density, namely, the Pearl River Delta region, eastern Guangdong, western Guangdong, and northern Guangdong;

(2) Second-stage sampling: County-level administrative departments are sampled within each region using an equal-proportional sampling method to ensure that the sampling weights are proportional to the size of the permanent population aged 18 years and above in each region;

(3) Third-stage sampling: Communities/administrative villages are randomly selected in the selected counties and districts according to the ratio of urban to rural population;

(4) Final sampling unit: Random sampling of households is conducted in selected communities to ensure equal probability of selection of individuals within households.

The sample size calculation formula is as follows.

$$n = \frac{Z^2 \times p(1-p)}{e^2} \quad (4.9)$$

The Z value is taken as 1.96 (corresponding to 95% confidence level), p value is taken as 0.5, and the allowable error $e = 3\%$. The minimum sample size is calculated to be 1,067. Taking into account the questionnaire response rate (85%), the need for stratified analysis and the need for finer statistical validity of the subgroups, the final sample size is determined to be 3,000. This sample size can provide more adequate support for the analysis of multi-dimensional demographic subgroups (such as different age groups and occupational groups), ensure the stability of parameter estimation and the validity of statistical tests of subgroups. In addition, redundancy space is reserved for potential data cleaning and invalid questionnaire elimination.

4.2.10.3 Research content

The research content of this study mainly focuses on the allocation of health resources and the health status of residents in Guangdong Province, and is specifically composed of the following aspects.

1. Analysis of the current situation of health resource allocation

This study analyzes the status quo of health resource allocation in different regions of Guangdong Province, with core variables including distribution of medical institutions, satisfaction with medical equipment, perception of the number of healthcare workers, and evaluation of government funding. Descriptive statistics and inter-regional comparisons (chi-square test) are used to reveal regional differences in health resource allocation within Guangdong Province.

2. Analysis of differences in residents' health level

Health literacy is assessed through a series of questions testing knowledge of common health conditions and preventive practices, while health self-assessment is captured via a

standard five-point scale from "excellent" to "poor." The calculation of age-standardized prevalence rates for chronic conditions is crucial for enabling fair comparisons across regions with differing demographic structures, as it controls for the confounding effect of population age distribution on morbidity rates. The study further explores the health differences of residents in different regions of Guangdong Province, with core variables including chronic disease prevalence, health literacy and health self-assessment. Through calculation of the prevalence of chronic diseases (such as hypertension and diabetes) in each region, regional differences in the health status of residents are analyzed.

3. Correlation analysis of resource allocation and health disparities

A multivariate regression model is constructed in this study. Health indicators are the dependent variables, and healthcare resource indicators are the independent variables, with demographic variables such as gender, age, and literacy controlled. Through hypothesis testing, this study explores whether the health risks of residents in areas with insufficient health resources are significantly higher than those in the PRD region.

4. Research on health service utilization behavior

Finally, the study focuses on residents' health service utilization behavior, with core issues including residents' choice of treatment, perception of queuing time, and evaluation of service attitude. The analysis focuses on whether areas with insufficient resources rely more on lower-level healthcare institutions or self-medication, so as to reveal the impact of resource allocation on residents' medical treatment behavior.

With the above research content, this study aims to comprehensively analyze the current situation of healthcare resource allocation in Guangdong Province and its impact on residents' health, so as to provide a scientific basis for the optimization of resource allocation and improvement of residents' health.

4.2.10.4 Statistical analysis methods

In this study, descriptive statistics, chi-square test and non-parametric test are applied to analyze the correlation between healthcare resource allocation and residents' health status in Guangdong Province. First, the distribution characteristics of core variables such as the distribution of healthcare institutions and satisfaction are presented through descriptive statistics. Subsequently, the chi-square test is applied to compare the differences of variables in different regions, so as to reveal the regional characteristics of resource distribution. Furthermore, the prevalence of chronic diseases in each region is calculated to further quantify the differences in residents' health. In addition, non-parametric test is used to compare the

healthcare utilization behaviors of residents in different regions, and the impact of resource accessibility on the choice of treatment, queuing time and service experience is assessed in multiple dimensions, so as to comprehensively and systematically explain the complex relationship between healthcare resource allocation and the health status of residents in Guangdong Province. The specific methods are as follows.

1. Descriptive statistics and inter-regional comparison

This study begins with a descriptive statistical analysis of the status quo of health resource allocation, with core variables including the distribution of medical institutions, satisfaction with medical equipment, perceived number of healthcare workers, and evaluation of government funding. The distribution characteristics of each variable are demonstrated by calculating the frequency and proportion. For continuous variables, measures of central tendency (mean, median) and dispersion (standard deviation, interquartile range) are calculated to provide a comprehensive overview of the data distribution. For categorical variables, frequency distributions and cross-tabulations are generated to illustrate proportional differences across population subgroups and geographical regions. To further reveal regional differences, the distribution of the variables among different regions is compared using the chi-square test to test whether there are significant differences between regions.

2. Calculation of chronic disease prevalence and health disparity analysis

This study analyzes regional differences in the health status of residents by calculating the prevalence of chronic diseases (such as hypertension and diabetes) in each region.

3. Descriptive analysis of healthcare service utilization behavior and inter-regional comparison

This study analyzes residents' healthcare service utilization behavior through descriptive statistics, with core variables including choice of treatment, perceived queuing time and evaluation of service attitude. Non-parametric test is further adopted to compare the differences in healthcare service utilization behavior between residents in areas with insufficient and abundant resources, so as to explore the impact of resource distribution on residents' health seeking behavior.

Through the above statistical analysis methods, this study systematically analyzes the current situation of healthcare resource allocation in Guangdong Province and its impact on residents' health, which provides a scientific basis for the optimization of resource allocation and improvement of residents' health

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Chapter 5: Results

5.1 Distribution of health resources and health status of residents in Guangdong Province

5.1.1 Overview of the distribution of healthcare institutions in different regions of Guangdong Province

According to Table 5.1, during the ten years from 2011 to 2020, the number of healthcare institutions in Guangdong rose from 16,904 to 55,162, with an increase of 38,258 (226.33%); the number of healthcare institutions in the Pearl River Delta (PRD) rose from 10,171 to 26,391, with an increase of 16,220 (92.94%); the number of healthcare institutions in eastern Guangdong rose from 3,187 to 11,147, with an increase of 7,960 (41.58%); the number of healthcare institutions in western Guangdong rose from 1,773 to 8,812, with an increase of 7,039 (35.20%); and the number of healthcare institutions in mountainous areas rose from 1,831 to 9,550, with an increase of 7,719 (36.50%). From 2011 to 2020, the number healthcare institutions in Guangdong increased significantly in both quantity and rate, and the Pearl River Delta (PRD) has the largest growth rate, followed by eastern Guangdong, mountainous region, and western Guangdong, indicating that the efforts in the construction of healthcare institutions in the PRD region are greater than other regions over the past decade. In 2016, the healthcare institutions in Guangdong witnessed the highest growth rate, which is due to the fact that since 2016, village health stations have been additionally included in the statistics of healthcare institutions. Judging from the growth rate of each region from 2016 to 2020, it can be seen that most of the newly included healthcare institutions in the eastern, mountainous, and western regions of Guangdong are village health stations, which are small in size, large in quantity, and widespread in distribution, and are the main healthcare institutions providing basic healthcare services to the residents in these three regions. On the other hand, most of the healthcare institutions in the PRD region are large general hospitals.

In terms of the number of healthcare institutions per 1,000 population, this figure has been increasing year by year during the decade from 2011 to 2020 in Guangdong, and the number of healthcare institutions per 1,000 population in the four regions, namely, the Pearl River Delta (PRD) region, eastern Guangdong, western Guangdong, and mountainous region, has been on

the rise as well. Comparison among regions shows that the number of healthcare institutions per 1,000 population in the PRD is much higher than that in the eastern, western and mountainous regions. From a comparative analysis of healthcare institutions per 1,000 population between the PRD region and other regions, the multiple of the difference in healthcare institutions per 1,000 population from 2011 to 2020 is shrinking, indicating that the investment in healthcare resources in Guangdong is relatively balanced across the regions, and the disparity between the various regions in terms of healthcare institutions is gradually narrowing.

Table 5.1 Number of healthcare institutions per 1,000 population in different regions of Guangdong from 2011 to 2020

Year	Total number in Guangdong	Number per 1,000 population in Guangdong	Total number in PRD	Number per 1,000 population in PRD	Total number in eastern Guangdong	Number per 1,000 population in eastern Guangdong	Total number in western Guangdong	Number per 1,000 population in western Guangdong	Total number in mountainous region	Number per 1,000 population in mountainous region	PRD/eastern Guangdong (multiple)	PRD/western Guangdong (multiple)	PRD/mountainous region (multiple)
2011	16904	0.2000	10171	0.3137	3187	0.1663	1773	0.1213	1831	0.1000	1.8864	2.5856	3.1363
2012	17452	0.2058	10494	0.3186	3222	0.1700	1868	0.1269	1886	0.1036	1.8746	2.5103	3.0749
2013	19142	0.2227	11595	0.3456	3279	0.1713	2134	0.1432	2080	0.1132	2.0173	2.4126	3.0531
2014	19997	0.2290	12366	0.3616	3159	0.1637	2236	0.1481	2164	0.1155	2.2086	2.4411	3.1303
2015	21148	0.2388	13566	0.3905	3196	0.1632	2193	0.1438	2234	0.1176	2.3919	2.7151	3.3189
2016	48004	0.5322	20378	0.5704	11256	0.5649	8185	0.5348	9305	0.4837	1.0096	1.0664	1.1792
2017	48942	0.5334	21228	0.5740	11074	0.5551	8320	0.5388	9304	0.4801	1.0341	1.0654	1.1956
2018	50478	0.5412	22891	0.5989	10953	0.5476	8317	0.5364	9366	0.4793	1.0937	1.1166	1.2494
2019	53072	0.5585	25023	0.6313	11009	0.5463	8520	0.5480	9376	0.4759	1.1556	1.1520	1.3266
2020	55162	0.5754	26391	0.6630	11147	0.5477	8812	0.5588	9550	0.4787	1.2105	1.1864	1.3849

Note: Data sources: Guangdong Statistical Yearbook (2011–2020) and Statistical Yearbooks of Prefectural-level Cities in Guangdong Province.

5.1.2 Overview of the distribution of healthcare professionals in different regions of Guangdong Province

Based on the statistical data from the *Guangdong Provincial Statistical Yearbook*, the healthcare professionals in each region are divided into three main categories: healthcare workers, healthcare technicians, and practicing (assistant) physicians, and the analysis of the specific distribution of these personnel in each region is directly based on the data from the *Guangdong Provincial Statistical Yearbook*.

Table 5.2 shows that from 2011 to 2020, the number of healthcare workers in Guangdong rose from 582,244 to 1,009,408, with an increase of 427,164 (73.37%); the number of healthcare workers in the Pearl River Delta (PRD) rose from 381,867 to 661,098, with an increase of 279,231 (73.12%); the number of healthcare workers in eastern Guangdong rose from 77,404 to 133,460, with an increase of 56,056 (72.42%); the number of healthcare workers in western Guangdong rose from 55,647 to 97,018, with an increase of 41,371 (74.35 %); and the number of healthcare workers in the mountainous region rose from 67,326 to 117,832, with an increase of 50,506 (75.02%). It can be found that from 2011 to 2020, the number of healthcare technicians in Guangdong increased significantly, and the mountainous region has the highest growth rate, followed by western Guangdong, the Pearl River Delta, and eastern Guangdong. The number of healthcare workers per 1,000 population in Guangdong rose from 6.8891 to 10.5287, the number of healthcare workers per 1,000 population in the PRD region rose from 11.7764 to 16.6088, the number of healthcare workers per 1,000 population in eastern Guangdong rose from 4.0384 to 6.5580, the number of healthcare workers per 1,000 population in western Guangdong rose from 3.8075 to 6.1527, and the number of healthcare workers per 1,000 population in the mountainous region rose from 3.6774 to 5.9068. The proportions of healthcare workers per 1,000 population in the PRD region to those in eastern and western Guangdong show a downward trend, while the proportion of healthcare workers per 1,000 population in the PRD region to those in the mountainous region shows a downward and then a slight upward trend.

Table 5.3 shows that from 2011 to 2020, the number of healthcare technicians in Guangdong rose from 476,446 to 832,061, with an increase of 355,615 (74.64%); the number of healthcare technicians in the Pearl River Delta (PRD) region rose from 312,068 to 549,762, with an increase of 237,694 (76.17%); the number of healthcare technicians in eastern Guangdong rose from 64,768 to 109,753, with an increase of 44,985 (69.46%); the number of healthcare technicians in western Guangdong rose from 44,654 to 77,880, with an increase of

33,226 (74.41%); and the number of healthcare technicians in the mountainous region rose from 54,956 to 94,666, with an increase of 39,710 (72.26%). It can be found that from 2011 to 2020, the number of healthcare technicians in Guangdong increased significantly, and the Pearl River Delta (PRD) region witnessed the highest growth rate, followed by western Guangdong, mountainous region, and eastern Guangdong. The number of healthcare technicians per 1,000 population in Guangdong rose from 3.6924 to 5.7344, the number of healthcare technicians per 1,000 population in the Pearl River Delta (PRD) region rose from 9.6239 to 13.8117, the number of healthcare technicians per 1,000 population in eastern Guangdong rose from 3.3792 to 5.3931, the number of healthcare technicians per 1,000 population in western Guangdong rose from 3.0554 to 4.9390, and the number of healthcare technicians per 1,000 population in the mountainous region rose from 3.0017 to 4.7455. The proportions of healthcare technicians per 1,000 population in the PRD region to those in eastern and western Guangdong are on a downward trend, while the proportion of healthcare technicians per 1,000 population in the PRD region to those in the mountainous region shows a downward and then slightly upward trend.

Table 5.4 shows that from 2011 to 2020, the number of practicing (assistant) physicians in Guangdong rose from 179,381 to 307,289, with an increase of 127,908 (71.31%); the number of practicing (assistant) physicians in the PRD region rose from 111,274 to 202,116, with an increase of 90,842 (81.64%), the number of practicing (assistant) physicians in eastern Guangdong rose from 25,134 to 39,231, with an increase of 14,097 (56.09%); the number of practicing (assistant) physicians in western Guangdong rose from 21,960 to 31,917, with an increase of 9,957 (45.34%); and the number of practicing (assistant) physicians in the mountainous region rose from 21,013 to 34,025, with an increase of 13,012 (61.92%). From 2011 to 2020, the number of practicing (assistant) physicians in Guangdong increased significantly, and the PRD region witnessed the highest growth, followed by the mountainous region, eastern Guangdong, and western Guangdong. The number of practicing (assistant) physicians per 1,000 population in Guangdong rose from 2.1224 to 3.2052, the number of practicing (assistant) physicians per 1,000 population in the PRD region rose from 3.4316 to 5.0778, the number of practicing (assistant) physicians per 1,000 population in eastern Guangdong rose from 1.3113 to 1.9278, and the number of practicing (assistant) physicians per 1,000 population in western Guangdong rose from 1.3113 to 1.9278. The proportions of practicing (assistant) physicians per 1,000 population in the PRD region to those in eastern and western Guangdong shows a downward trend, while the proportion of practicing (assistant) physicians per 1,000 population in the PRD region to those in the mountainous region shows a

downward and then slightly upward trend.

In summary, from the overall situation of the Guangdong Province, the healthcare personnel resources in the PRD region are better than those in other regions. In terms of healthcare professionals, the number of healthcare workers, healthcare technicians and practicing (assistant) physicians has been rising year by year, and the smallest increase is in practicing (assistant) physicians per 1,000 population. Moreover, the Guangdong Provincial government has invested more healthcare personnel resources in the PRD region than other regions, but the gap between the PRD region and the regions in terms of resources for healthcare workers and healthcare technicians is decreasing, and the gap in terms of resources for practicing (assistant) physicians is stabilizing.

Table 5.2 Number of healthcare workers per 1,000 population in different regions of Guangdong from 2011 to 2020

Year	Total number in Guangdong	Number per 1,000 population in Guangdong	Total number in PRD	Number per 1,000 population in PRD	Total number in eastern Guangdong	Number per 1,000 population in eastern Guangdong	Total number in western Guangdong	Number per 1,000 population in western Guangdong	Total number in mountainous region	Number per 1,000 population in mountainous region	PRD/eastern Guangdong (multiple)	PRD/western Guangdong (multiple)	PRD/mountainous region (multiple)
2011	582244	6.8891	381867	11.7764	77404	4.0384	55647	3.8075	67326	3.6774	2.9161	3.0929	3.2024
2012	620173	7.3129	406171	12.3331	82412	4.3477	59392	4.0358	72198	3.9669	2.8367	3.0559	3.1090
2013	667072	7.7599	437623	13.0436	89799	4.6916	62483	4.1942	77167	4.1995	2.7802	3.1099	3.1060
2014	697202	7.9841	456330	13.3433	93376	4.8393	66528	4.4072	80968	4.3219	2.7573	3.0276	3.0873
2015	736665	8.3181	481750	13.8655	97907	5.0007	70538	4.6256	86470	4.5536	2.7727	2.9975	3.0450
2016	821880	9.1123	521093	14.5848	114221	5.7328	82444	5.3873	104122	5.4123	2.5441	2.7072	2.6947
2017	866925	9.4489	551861	14.9234	118573	5.9436	86583	5.6071	109908	5.6718	2.5108	2.6615	2.6311
2018	921703	9.8821	592932	15.5127	123399	6.1693	90311	5.8241	115061	5.8888	2.5145	2.6635	2.6343
2019	964914	10.1534	630662	15.9116	127894	6.3469	92324	5.9387	114034	5.7882	2.5070	2.6793	2.7490
2020	1009408	10.5287	661098	16.6088	133460	6.5580	97018	6.1527	117832	5.9068	2.5326	2.6994	2.8118

Note: Data sources: Guangdong Statistical Yearbook (2011–2020) and Statistical Yearbooks of Prefectural-level Cities in Guangdong Province.

Table 5.3 Number of healthcare technicians per 1,000 population in different regions of Guangdong from 2011 to 2020

Year	Total number in Guangdong	Number per 1,000 population in Guangdong	Total number in PRD	Number per 1,000 population in PRD	Total number in eastern Guangdong	Number per 1,000 population in eastern Guangdong	Total number in western Guangdong	Number per 1,000 population in western Guangdong	Total number in mountainous region	Number per 1,000 population in mountainous region	PRD/eastern Guangdong (multiple)	PRD/western Guangdong (multiple)	PRD/mountainous region (multiple)
2011	476446	3.6924	312068	9.6239	64768	3.3792	44654	3.0554	54956	3.0017	2.8480	3.1498	3.2061
2012	510288	3.9294	333230	10.1183	69560	3.6697	48394	3.2885	59104	3.2474	2.7573	3.0769	3.1158
2013	545562	4.1547	357154	10.6451	74871	3.9117	50340	3.3791	63197	3.4393	2.7213	3.1503	3.0952
2014	575725	4.3028	375739	10.9868	78539	4.0704	54155	3.5876	67292	3.5919	2.6992	3.0624	3.0587
2015	611647	4.4932	397925	11.4529	82517	4.2147	58634	3.8450	72571	3.8217	2.7174	2.9786	2.9968

The Impact of Uneven Allocation of Health Resources on Residents in Different Regions

2016	667525	4.7662	429884	12.0319	91262	4.5804	64489	4.2140	81890	4.2567	2.6268	2.8552	2.8266
2017	709894	4.9893	457763	12.3788	95721	4.7981	68936	4.4643	87474	4.5141	2.5799	2.7728	2.7422
2018	757840	5.2859	493015	12.8986	100327	5.0158	72256	4.6598	92242	4.7209	2.5716	2.7681	2.7322
2019	795132	5.5284	525383	13.2554	104654	5.1936	73774	4.7455	91321	4.6353	2.5523	2.7933	2.8596
2020	832061	5.7344	549762	13.8117	109753	5.3931	77880	4.9390	94666	4.7455	2.5610	2.7965	2.9105

Note: Data sources: Guangdong Statistical Yearbook (2011–2020) and Statistical Yearbooks of Prefectural-level Cities in Guangdong Province.

Table 5.4 Number of practicing (assistant) physicians per 1,000 population in different regions of Guangdong from 2011 to 2020

Year	Total number in Guangdong	Number per 1,000 population in Guangdong	Total number in PRD	Number per 1,000 population in PRD	Total number in eastern Guangdong	Number per 1,000 population in eastern Guangdong	Total number in western Guangdong	Number per 1,000 population in western Guangdong	Total number in mountainous region	Number per 1,000 population in mountainous region	PRD/eastern Guangdong (multiple)	PRD/western Guangdong (multiple)	PRD/mountainous region (multiple)
2011	179381	2.1224	111274	3.4316	25134	1.3113	21960	1.5026	21013	1.1477	2.6169	2.2838	2.9899
2012	192107	2.2653	118611	3.6015	27088	1.4290	23816	1.6184	22592	1.2413	2.5203	2.2254	2.9014
2013	203673	2.3693	126664	3.7753	28588	1.4936	24250	1.6278	24171	1.3154	2.5276	2.3193	2.8700
2014	210658	2.4124	130912	3.8279	29393	1.5233	24819	1.6442	25534	1.3630	2.5129	2.3282	2.8085
2015	222663	2.5142	139038	4.0017	30988	1.5828	25651	1.6821	26986	1.4211	2.5283	2.3790	2.8159
2016	244139	2.7068	151725	4.2466	34348	1.7239	28267	1.8471	29799	1.5490	2.4633	2.2991	2.7416
2017	258889	2.8217	163283	4.4155	34567	1.7327	29666	1.9212	31373	1.6190	2.5483	2.2983	2.7273
2018	277362	2.9738	177627	4.6472	35705	1.7851	30755	1.9834	33275	1.7030	2.6034	2.3431	2.7288
2019	292128	3.0739	191222	4.8245	37495	1.8607	30899	1.9876	32512	1.6503	2.5928	2.4274	2.9235
2020	307289	3.2052	202116	5.0778	39231	1.9278	31917	2.0241	34025	1.7056	2.6340	2.5086	2.9770

Note: Data sources: Guangdong Statistical Yearbook (2011–2020) and Statistical Yearbooks of Prefectural-level Cities in Guangdong Province.

5.1.3 Overview of the distribution of beds in healthcare institutions in different regions of Guangdong Province

Table 5.5 shows that from 2011 to 2020, the total number of beds in healthcare institutions in Guangdong rose from 246,050 to 459,045, with an increase of 212,995 (86.57%); the total number of beds in healthcare institutions in the PRD region increases from 162,199 to 284,626, with an increase of 122,427 (75.48%); the total number of beds in healthcare institutions in eastern Guangdong rose from 23,393 to 48,504, with an increase of 25,111 (107.34%); the total number of beds in healthcare institutions in western Guangdong rose from 29,600 to 66,499, with an increase of 36,899 (124.66%); and the total number of beds in mountainous region rose from 30,858 to 59,416, with an increase of 28,558 (92.55%). The total number of beds in the healthcare institutions of Guangdong increased significantly, and western Guangdong witnessed the highest growth, followed by eastern Guangdong, the mountainous region, and the PRD region. It is worth noting that both western and eastern Guangdong have an increase of more than 100 percent. The number of beds in healthcare institutions per 1,000 population in Guangdong rose from 2.9113 to 4.7881, the number of beds in healthcare institutions per 1,000 population in the PRD region rose from 5.0021 to 7.1507, the number of beds in healthcare institutions per 1,000 population in eastern Guangdong rose from 1.2205 to 2.3834, the number of beds in healthcare institutions per 1,000 population in western Guangdong rose from 2.0253 to 4.2172, and the number of beds per 1,000 population in mountainous region rose from 1.6855 to 2.9785. All the figures in the four regions show a steady upward trend. From 2011 to 2020, in terms of the number of beds in healthcare institutions, the PRD region has far more beds than the other regions. However, the Guangdong government has invested more resources in the western, eastern and mountainous regions of Guangdong than the PRD region, and the disparity between the PRD region and the other regions in terms of beds in healthcare institutions has been gradually diminishing.

Table 5.5 Number of beds in healthcare technicians per 1,000 population in different regions of Guangdong from 2011 to 2020

Year	Total number in Guangdong	Number per 1,000 population in Guangdong	Total number in PRD	Number per 1,000 population in PRD	Total number in eastern Guangdong	Number per 1,000 population in eastern Guangdong	Total number in western Guangdong	Number per 1,000 population in western Guangdong	Total number in mountainous region	Number per 1,000 population in mountainous region	PRD/eastern Guangdong (multiple)	PRD/western Guangdong (multiple)	PRD/mountainous region (multiple)
2011	246050	2.9113	162199	5.0021	23393	1.2205	29600	2.0253	30858	1.6855	2.9678	4.0984	2.9678
2012	272873	3.2176	182539	5.5427	24782	1.3074	33390	2.2689	32162	1.7671	3.1365	4.2395	3.1365
2013	294219	3.4226	193759	5.7751	26946	1.4078	36896	2.4766	36618	1.9928	2.8980	4.1022	2.8980
2014	319729	3.6614	208405	6.0939	29235	1.5151	42219	2.7968	39870	2.1282	2.8634	4.0220	2.8634
2015	345258	3.8985	223695	6.4383	32479	1.6589	46475	3.0477	42609	2.2438	2.8693	3.8810	2.8693
2016	371602	4.1200	238526	6.6760	36161	1.8149	50330	3.2888	46585	2.4215	2.7570	3.6784	2.7570
2017	393449	4.2883	248545	6.7211	39121	1.9610	55840	3.6162	49943	2.5773	2.6078	3.4274	2.6078
2018	416282	4.4632	261550	6.8429	42027	2.1011	59281	3.8230	53424	2.7342	2.5027	3.2567	2.5027
2019	441895	4.6499	276360	6.9725	44918	2.2291	63385	4.0772	57232	2.9050	2.4002	3.1280	2.4002
2020	459045	4.7881	284626	7.1507	48504	2.3834	66499	4.2172	59416	2.9785	2.4008	3.0002	2.4008

Note: Data sources: Guangdong Statistical Yearbook (2011–2020) and Statistical Yearbooks of Prefectural-level Cities in Guangdong Province.

5.1.4 Overview of medical expenditure in different regions of Guangdong Province

The Guangdong Provincial Bureau of Statistics has been compiling statistics on the fiscal revenues and expenditures of the four regions since 2015, and the data from 2011 to 2014 are collected from the statistical yearbooks of the cities in Guangdong, so there is a certain bias due to the fact that a few cities did not compile the statistics (data from Dongguan and Jiangmen is missing for the Pearl River Delta region, data from Shanwei is missing for western Guangdong, and data from Zhanjiang and Maoming is missing for the mountainous region).

Supplemental Table a.8 shows that from 2011 to 2020, the medical expenditure in Guangdong rose from 43,375,000,000 *yuan* to 177,299,000,000 *yuan*, with an increase of 133,924,000,000 *yuan* (308.76 %); the medical expenditure in the PRD region rose from 3,049,400,000 *yuan* to RMB 12,888,870,000 *yuan*, with an increase of 9,883,930,000 *yuan* (328.92%); the medical expenditure in eastern Guangdong rose from 1,206,880,000 *yuan* to 4,384,910,000 *yuan*, with an increase of 2,905,440,000 *yuan* (213.47%); the medical expenditure in western Guangdong rose from 1,361,070,000 *yuan* to 4,266,500,000 *yuan*, with an increase of 4,677,320,000 *yuan* (515.69%); and the medical expenditure in the mountainous region rose from 907,000,000 *yuan* to 5,584,320,000 *yuan*, with an increase of 3,178,030,000 *yuan* (263.33%). Western Guangdong has the highest growth, followed by the PRD region, the mountainous region, and eastern Guangdong. Considering that there is bias in the data, if 2015 is taken as the starting statistical year, the medical expenditure of the PRD region increased by 7,181,670,000 *yuan*, with an increase of 125.84%; the medical expenditure of eastern Guangdong increased by 1,396,090,000 *yuan*, with an increase of 48.64%; the medical expenditure of western Guangdong increased by 1,736,430,000 *yuan*, with an increase of 45.13%; and medical expenditure of the mountainous region increased by 1,522,070,000 *yuan*, with an increase of 53.17%. The PRD region has the highest growth, followed by the mountainous region, eastern Guangdong, and western Guangdong. The growth rate in the PRD region has exceeded 100%, while the growth rates in the other three regions are similar.

Supplemental Table a.9 shows that from 2011 to 2020, the proportion of medical expenditure to public budget expenditure in Guangdong rose from 6.4619 to 10.1716, with an increase of 3.7097; the proportion of medical expenditure to public budget expenditure in the PRD region rose from 6.4619 to 10.1716, with an increase of 4.9013, the proportion of medical expenditure to public budget expenditure in eastern Guangdong dropped from 13.1995 to 11.6546, with a decrease of 1.5449; the proportion of medical expenditure to public budget expenditure in western Guangdong rose from 13.1995 to 13.2767, basically remaining

unchanged; and the proportion of medical expenditure to public budget expenditure in the mountainous region rose from 5.9871 to 13.2103, with an increase of 7.2232. If 2015 is taken as the starting statistical year, the proportion of medical expenditure to public budget expenditure in the PRD rose by 3.9544, the proportion of medical expenditure to public budget expenditure in eastern Guangdong rose by 1.2958, the proportion of medical expenditure to public budget expenditure in western Guangdong rose by 0.7759, and the proportion of medical expenditure to public budget expenditure in the mountainous region rose by 0.7983. In terms of disposable income per capita, since there was no statistical data on per capita disposable income in Guangdong until 2013, and data in 2011 and 2012 was the average value of each region, there is measurement bias in the data. However, it is clear that the per capita disposable income has been steadily increasing in all regions, and the gap of disposable income per capital between the PRD region and the other regions remains relatively stable, which is shown as per Supplemental Table a.10.

It can be found that between 2011 and 2020, with the rapid growth of GDP and increase of the per capita disposable income in Guangdong, the government's healthcare expenditure is also increasing greatly, but the government healthcare expenditure in the PRD region is much higher than that in other regions. In addition, although the amount of government healthcare expenditure in other regions is lower than that in the PRD region, their proportions of government healthcare expenditure to total public budget expenditure are higher than that of the PRD region. The proportions of government healthcare expenditure in the PRD Region to government healthcare expenditures in other regions within Guangdong are on an upward trend, which indicates that the gap of government healthcare expenditure between the PRD region and other regions is widening.

5.2 Analysis of equity and efficiency of healthcare resource allocation in Guangdong Province

5.2.1 Health agglomeration analysis

5.2.1.1 Agglomeration of health resources by geographical distribution

From 2011 to 2020, the health resource agglomeration in the PRD and eastern Guangdong are both greater than 1.00 and basically show an increasing trend year by year, with the PRD having the highest agglomeration of all types of health resources (Table 5.6). The annual health resource agglomeration degree in the mountainous region is much smaller than 1.00, and the

geographic accessibility of health resources has not improved. The health resource agglomeration degree of western Guangdong has been greater than 1.00 since 2016, but declined in 2020. There are large differences in the agglomeration degree of various types of health resources within Guangdong Province, with the largest gap between the mountainous region and the other three regions, followed by western Guangdong.

Table 5.6 Health resource agglomeration ratio of Guangdong Province from 2011 to 2020

	Year	PRD	Eastern Guangdong	Western Guangdong	Mountainous region
Healthcare institutions	2011	1.93	1.22	0.62	0.44
	2012	1.93	1.24	0.62	0.43
	2013	1.94	1.29	0.62	0.40
	2014	1.98	1.30	0.62	0.37
	2015	2.06	1.20	0.60	0.35
	2016	1.36	1.98	1.11	0.55
	2017	1.39	1.97	1.08	0.53
	2018	1.46	1.91	1.06	0.51
	2019	1.51	1.86	1.01	0.49
	2020	1.54	1.85	0.99	0.47
Beds	2011	2.12	1.39	0.72	0.22
	2012	2.15	1.42	0.67	0.21
	2013	2.11	1.45	0.71	0.21
	2014	2.09	1.53	0.71	0.21
	2015	2.08	1.56	0.70	0.22
	2016	2.06	1.57	0.72	0.23
	2017	2.03	1.65	0.72	0.23
	2018	2.02	1.65	0.73	0.24
	2019	2.01	1.66	0.74	0.24
	2020	1.99	1.68	0.74	0.25
Healthcare technicians	2011	2.10	1.09	0.66	0.32
	2012	2.10	1.10	0.66	0.32
	2013	2.10	1.07	0.66	0.32
	2014	2.09	1.09	0.67	0.32
	2015	2.09	1.11	0.68	0.32
	2016	2.07	1.12	0.70	0.32
	2017	2.07	1.13	0.70	0.32
	2018	2.09	1.11	0.69	0.31
	2019	2.12	1.08	0.66	0.31
	2020	2.12	1.09	0.65	0.31
Practicing (assistant) physicians	2011	1.99	1.42	0.67	0.33
	2012	1.98	1.44	0.67	0.33
	2013	2.00	1.38	0.68	0.33
	2014	1.99	1.37	0.69	0.33
	2015	2.00	1.34	0.69	0.33
	2016	1.99	1.34	0.70	0.33
	2017	2.02	1.33	0.69	0.31
	2018	2.06	1.29	0.68	0.30
	2019	2.10	1.23	0.63	0.30
	2020	2.11	1.20	0.63	0.30

5.2.1.2 Agglomeration of health resources by population distribution

Except for the PRD region where the ratio in 2016 showed a decrease compared with that in 2015, the ratios of all health resource agglomeration degrees in the other regions have been increasing year by year. Among them, the ratio in the PRD is the largest and the ratio in western Guangdong is the smallest, indicating that there is a relative surplus of health resources in the PRD region, which can basically meet the public demands. Among the four regions in Guangdong, the PRD has the highest agglomeration ratios for the number of healthcare institutions, beds, healthcare technicians, and practicing (assistant) physicians, while the agglomeration ratio for practicing (assistant) physicians in western Guangdong is the lowest (shown as per Table 5.7).

Table 5.7 Health resource agglomeration ratio of Guangdong Province from 2011 to 2020

	Year	PRD	Eastern Guangdong	Western Guangdong	Mountainous region
Healthcare institutions	2011	1.60	0.62	0.51	0.85
	2012	1.58	0.63	0.51	0.84
	2013	1.58	0.66	0.52	0.78
	2014	1.61	0.66	0.51	0.73
	2015	1.66	0.61	0.50	0.70
	2016	1.09	1.02	0.92	1.08
	2017	1.09	1.03	0.91	1.06
	2018	1.13	1.01	0.90	1.03
	2019	1.15	1.00	0.87	0.99
	2020	1.18	0.99	0.85	0.97
Beds	2011	1.76	0.71	0.59	0.43
	2012	1.75	0.72	0.56	0.41
	2013	1.72	0.74	0.59	0.42
	2014	1.69	0.78	0.59	0.42
	2015	1.68	0.80	0.59	0.43
	2016	1.65	0.81	0.60	0.45
	2017	1.59	0.86	0.61	0.46
	2018	1.56	0.87	0.62	0.48
	2019	1.52	0.89	0.64	0.49
	2020	1.53	0.90	0.64	0.51
Healthcare technicians	2011	1.74	0.55	0.54	0.61
	2012	1.71	0.56	0.55	0.62
	2013	1.71	0.54	0.55	0.63
	2014	1.70	0.55	0.55	0.63
	2015	1.69	0.57	0.56	0.62
	2016	1.65	0.58	0.58	0.63
	2017	1.62	0.59	0.59	0.63
	2018	1.62	0.58	0.59	0.63
	2019	1.61	0.58	0.56	0.63
	2020	1.63	0.58	0.56	0.64
Practicing	2011	1.65	0.72	0.55	0.63
	2012	1.62	0.73	0.56	0.64
	2013	1.62	0.70	0.57	0.64
	2014	1.61	0.69	0.57	0.64

	Year	PRD	Eastern Guangdong	Western Guangdong	Mountainous region
(assistant) physicians	2015	1.62	0.68	0.57	0.64
	2016	1.59	0.69	0.58	0.65
	2017	1.59	0.69	0.58	0.62
	2018	1.59	0.68	0.58	0.61
	2019	1.60	0.66	0.55	0.62
	2020	1.62	0.65	0.54	0.62

5.2.2 Gini coefficient analysis and Theil index analysis

As can be seen from Table 5.8 to Table 5.11, the Gini coefficients of the three population-weighted resources of healthcare institutions, healthcare technicians and beds vary in the range of 0.14 to 0.28, while the Theil index ranges from 0.04 to 0.17, indicating that the allocation of the above-mentioned resources in the demographic dimension is relatively well-balanced, and the overall allocation of these resources is in the relatively balanced and reasonable range.

In contrast, the Gini coefficients of geographically weighted resources of the same kind vary between 0.27 and 0.36, which is closer to the internationally recognized alert line of 0.4 than the population-weighted indicator. The Theil indexes vary between 0.12 and 0.22, which is significantly higher than the value of the same indicator in the population dimension, suggesting that there is a significant imbalance in the geospatial allocation of health resources in Guangdong Province.

Table 5.8 Gini coefficient of healthcare resources by population distribution in Guangdong Province from 2011 to 2020

Year	Healthcare institutions	Beds	Healthcare professionals
2011	0.142	0.196	0.231
2012	0.244	0.260	0.263
2013	0.248	0.272	0.257
2014	0.244	0.261	0.259
2015	0.232	0.256	0.255
2020	0.218	0.250	0.252
2017	0.200	0.237	0.224
2018	0.178	0.222	0.219
2019	0.161	0.210	0.220
2020	0.147	0.200	0.226

Table 5.9 Gini coefficient of healthcare resources by geographical distribution in Guangdong Province from 2011 to 2020

Year	Healthcare institutions	Beds	Healthcare professionals
2011	0.271	0.309	0.337
2012	0.303	0.342	0.337
2013	0.311	0.352	0.337
2014	0.308	0.341	0.336
2015	0.305	0.334	0.336
2020	0.292	0.332	0.336
2017	0.284	0.327	0.317

2018	0.271	0.318	0.320
2019	0.272	0.315	0.326
2020	0.271	0.312	0.335

Table 5.10 Theil index of healthcare resources by population distribution in Guangdong Province from 2011 to 2020

Year	Healthcare institutions	Beds	Healthcare professionals
2011	0.047	0.081	0.115
2012	0.120	0.154	0.150
2013	0.124	0.161	0.144
2014	0.119	0.146	0.144
2015	0.110	0.138	0.140
2020	0.096	0.132	0.138
2017	0.083	0.120	0.112
2018	0.065	0.103	0.107
2019	0.056	0.093	0.108
2020	0.049	0.084	0.111

Table 5.11 Theil index of healthcare resources by geographical distribution in Guangdong Province from 2011 to 2020

Year	Healthcare institutions	Beds	Healthcare professionals
2011	0.124	0.159	0.196
2012	0.158	0.201	0.197
2013	0.167	0.212	0.196
2014	0.164	0.199	0.197
2015	0.159	0.190	0.195
2020	0.143	0.186	0.195
2017	0.136	0.180	0.172
2018	0.123	0.169	0.175
2019	0.123	0.166	0.182
2020	0.123	0.163	0.194

5.2.3 Lorentz curve analysis

5.2.3.1 The Lorenz curve for the allocation of healthcare resources by population in Guangdong in 2020

Data on the allocation of healthcare resources by population in each region of Guangdong Province in 2020 are used to plot the Lorenz curve as shown in Figure 5.1. The figure shows that the number of healthcare institutions is less curved and closer to the line of perfect equality. However, the number of healthcare professionals and the number of healthcare beds are more curved. As a result, in 2020, allocation of healthcare institutions has the best equality, while allocation of the healthcare professionals as well as healthcare institutions has relatively poor equality in Guangdong Province.

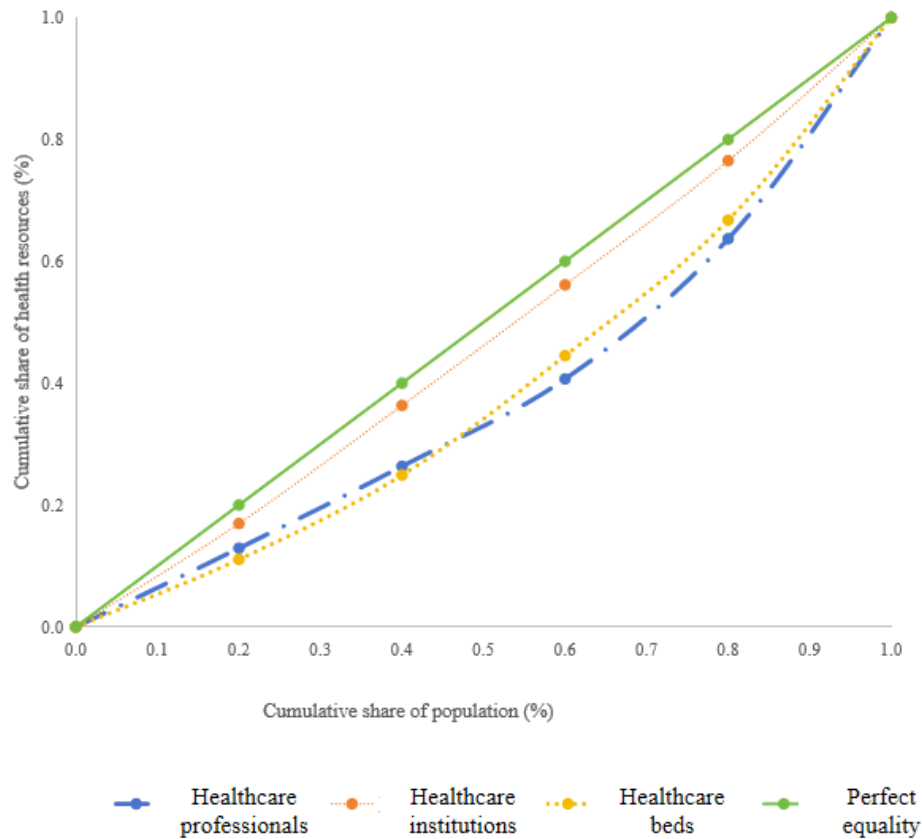


Figure 5.1 Lorenz curve of healthcare resource allocation by population in Guangdong in 2020

5.2.3.2 The Lorenz curve for the allocation of healthcare resources by per capita income in Guangdong in 2020

Data on the allocation of healthcare resources by per capita income in each region of Guangdong Province in 2020 are used to plot the Lorenz curve as shown in Figure 5.2. The figure shows that the number of healthcare institutions is less curved and closer to the line of perfect equality. However, the number of healthcare professionals and the number of healthcare beds are more curved, with the former being most curved. As a result, in 2020, allocation of healthcare institutions has the best equality, while allocation of the healthcare professionals as well as healthcare institutions has relatively poor equality in Guangdong Province.

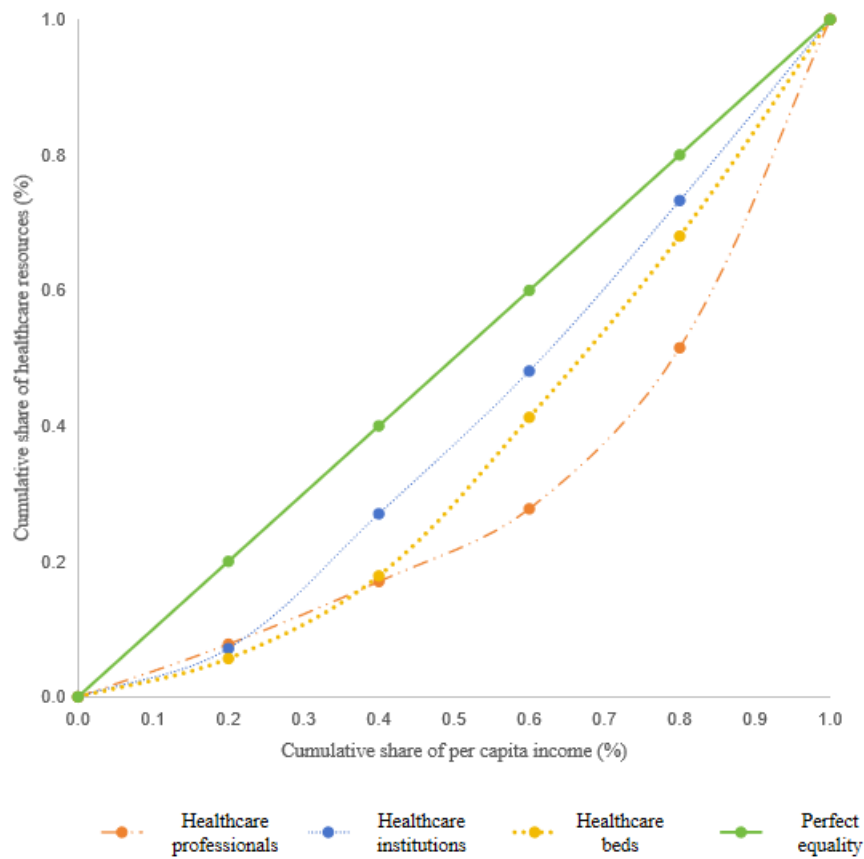


Figure 5.2 Lorenz curve of healthcare resource allocation by per capita income in Guangdong in 2020

5.2.4 DEA model analysis

5.2.4.1 Analysis of the time dimension

First, we compare the changes in the average value of efficiency of Guangdong Province as a whole from 2011 to 2020 horizontally in the time dimension. As shown in Table 5.12 and Figure 5.3, the mean value of overall technical efficiency shows significant fluctuations in 2013 and 2015. The mean value of the overall technical efficiency of government healthcare expenditure and per capita disposable healthcare expenditure in Guangdong province during the entire sample period is 0.96, which is not a DEA efficient state, representing that the overall utilization of healthcare inputs is not optimal. In addition, the mean values of the overall technical efficiency in all years during the sample period are below 1, with the lowest being 0.91 in 2015 and the highest being 0.97 in 2011, 2012, 2014, 2017 and 2018, but none of them have reached the DEA efficient state.

In terms of pure technical efficiency, the trend of changes in the average value of pure

technical efficiency from 2011 to 2020 is basically the same as that of overall technical efficiency: decline from 2011 to 2013, significant fluctuation along with the overall efficiency in 2015, and stabilization since 2016. The highest value of this indicator is 1.00 in 2011 (DEA efficient), and the lowest value is 0.97 in 2014 and 2015, indicating that the effectiveness of healthcare fund management and the rationality of resource allocation in Guangdong Province are at a high level, but there is still room for improvement.

In terms of scale efficiency, scale efficiency in Guangdong Province shows cyclical fluctuations during the sample period, with phased declines in 2013 and 2015, but the highest value of 0.99 and the lowest value of 0.93 are both at a relatively high level, reflecting that the scale efficiency of the healthcare expenditure in Guangdong is in a good state. The mean value of scale efficiency is 0.98, which is consistent with that of the pure technical efficiency, indicating that the two contribute equally to overall technical efficiency.

In summary, the efficiency of healthcare expenditure in Guangdong Province from 2011 to 2020 shows significant fluctuations in different stages, and a coordinated optimization mechanism for overall technical efficiency, pure technical efficiency and scale efficiency has not been fully established. In the future, on the basis of maintaining the existing efficiency level, it is necessary to build a long-term optimization mechanism through technical efficiency improvement and scale restructuring, so as to achieve a substantial breakthrough in the efficiency of healthcare resource allocation.

Table 5.12 Mean value of three types of efficiency in five major regions of Guangdong (2011-2020)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Overall technical efficiency	0.97	0.97	0.94	0.97	0.91	0.96	0.97	0.97	0.96	0.96	0.96
Pure technical efficiency	1.00	0.99	0.98	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98
Scale efficiency	0.98	0.98	0.96	0.99	0.93	0.99	0.99	0.99	0.98	0.98	0.98

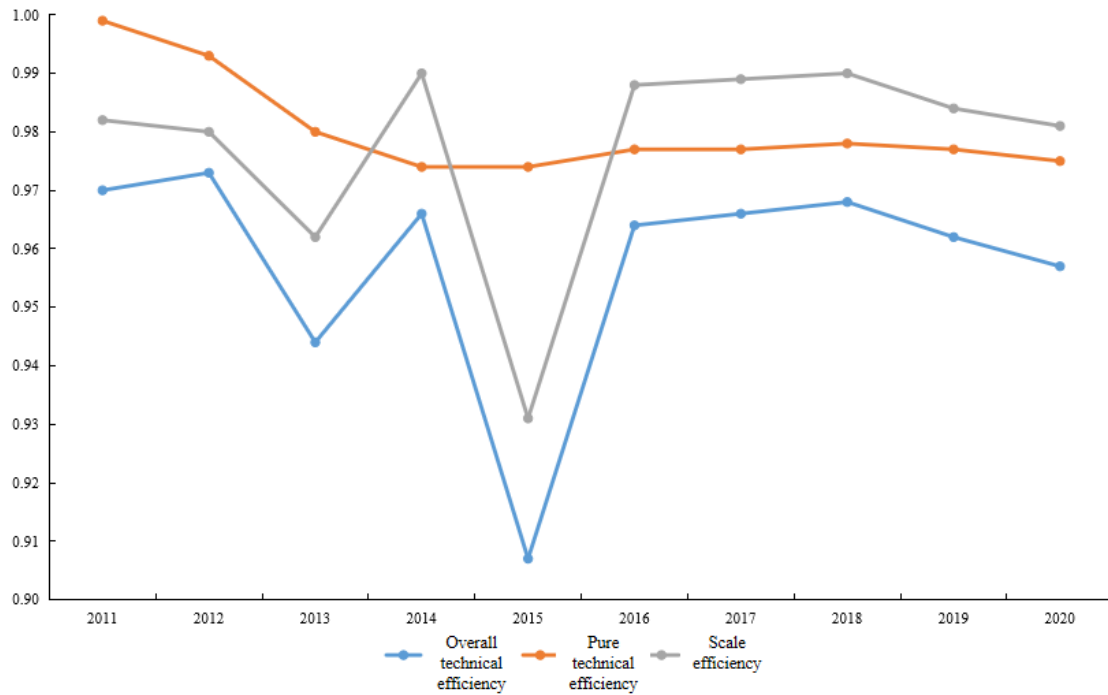


Figure 5.3 Mean value of three types of efficiency in five major regions of Guangdong (2011-2020)

5.2.4.2 Analysis of regional disparity

According to Table 5.13, there are disparities among the regions in terms of overall technical efficiency, but in general the overall technical efficiency is relatively high in all regions. As for the 10-year mean value of overall technical efficiency in each region, only the PRD region among the five regions is always in the DEA efficient state, and the overall technical efficiency of the remaining regions has changed to a greater or lesser extent. The 10-year mean values of the overall technical efficiency of eastern Guangdong are all around 1.00, which are close to DEA efficiency; the mean values of the overall technical efficiency of western Guangdong and the mountainous region are between 0.90 and 0.97; and the mean values of the overall technical efficiency of Guangdong Province as a whole are relatively low, but are also above 0.85. The highest mean value of the overall technical efficiency is 1.00, and the lowest mean value is 0.89, with a difference of 0.11.

In terms of the magnitude of change over the 10 years, eastern Guangdong has a very small magnitude of change and basically stays in the DEA efficient state, and western Guangdong basically has no change from 2014 to 2020; the mountainous region of Guangdong was in the DEA efficient state in the first 4 years, but declined considerably in 2015, and then reverted back to the weak DEA efficiency state in 2016; however, the change of the efficiency for Guangdong as a whole is relatively huge, and in general, it first shows a downward trend and

then presents an upward trend, but never reaches DEA efficiency. It indicates that these regions are affected by certain factors during the sample period that lead to a decline in overall technical efficiency, after which the municipal governments make efforts to improve the efficiency of healthcare expenditure and have achieved certain results. The overall technical efficiency begins to rebound, but the efficiency of healthcare expenditure in each region still has room for further improvement. In terms of economic development, the PRD region has a reasonable distribution of healthcare resources. It has a high level of capital management of the healthcare budget, and the scale of healthcare has reached the optimal level required by each region.

Table 5.13 Overall technical efficiency of different regions in Guangdong Province from 2011 to 2020

Region	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Mean
Guangdong	0.93	0.94	0.88	0.83	0.83	0.88	0.89	0.89	0.90	0.89	0.89
PRD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Eastern Guangdong	1.00	1.00	1.00	1.00	0.94	1.00	1.00	1.00	1.00	1.00	0.99
Western Guangdong	0.92	0.93	0.84	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97
Mountainous region	1.00	1.00	1.00	1.00	0.77	0.94	0.95	0.95	0.92	0.89	0.94

The specific changes of pure technical efficiency in each region are shown as per Supplemental Table a.11. From 2011 to 2020, the pure technical efficiency in each region is relatively high, representing a high level of health fund management and health resource allocation capacity. The highest mean value pure technical efficiency is 1.00 in the PRD region and eastern Guangdong, and the lowest value is the province-wide pure technical efficiency value, with a difference of 0.08, slightly smaller than that of the overall technical efficiency.

The specific changes of scale efficiency in each region are shown as per Supplemental Table a.12. From 2011 to 2020, there are still differences in the scale efficiency among the regions, but the gap is much narrower compared to the overall technical efficiency and pure technical efficiency. The scale efficiencies of all regions over the 10 years are above 0.95, staying at a relatively high level. In terms of the mean value of scale efficiency, only the PRD region has a 10-year average scale efficiency of 1, which reaches DEA efficiency. The mean values of scale efficiency in the remaining four regions are between 0.9 and 1, with the lowest being the province-wide scale efficiency of 0.90. The mean values of scale efficiency in eastern and western Guangdong are both 0.99, which are close to DEA efficiency.

5.2.4.3 Analysis of healthcare resource allocation in Guangdong Province based on the entropy power method

The raw indicators of the five variables such as basic healthcare facilities and healthcare human resources in each region of Guangdong Province in 2020 are standardized, and the information

entropies of healthcare resource allocation by year between 2011 and 2020 are calculated through the formula respectively. At the same time, the information entropies of healthcare resource allocation in the three years of 2011, 2015, and 2020 are also calculated as shown in Supplemental Table a.13 and Supplemental Table a.14. The results show that the size of the information entropy in healthcare resource allocation in Guangdong is roughly the same every year, and at the same time, the information entropy provided by each region of Guangdong Province during the three years of 2011, 2015, and 2020 is also roughly the same. It suggests that there is not much variation in the indicator values among the regions in Guangdong Province from 2011 to 2020 and between 2011, 2015, and 2020, and there is not much difference in the role played in the comprehensive evaluation.

The raw data are standardized again, and the entropy of each indicator (as per Supplemental Table a.15) is calculated according to the information entropy obtained from the results in Supplemental Table a.14 and the total weight of each indicator during the three years is calculated (as per Supplemental Table a.16). As shown in the results, the number of healthcare institutions per 1,000 population has the lowest weight, the number of healthcare professionals per 1,000 population has the largest weight, and the weights of other indicators do not differ much from each other. The results suggest that there is inequity in the allocation of healthcare resources in Guangdong, and this inequity mainly exists among healthcare technicians and healthcare workers, while the number of healthcare institutions is oversaturated.

5.3 Analysis of the correlation between healthcare resources and residents' health in Guangdong Province

5.3.1 Two-way fixed effects model analysis

From 2011 to 2020, when the number of hospital beds per 1,000 population in different regions of Guangdong Province is used as an indicator of the explanatory variable, the coefficients of the number of hospital beds per 1,000 population in different regions of Guangdong Province are significantly negative at the 1% level (-4.28, -4.43), indicating that the increase in the number of hospital beds per 1,000 population in different regions of Guangdong Province leads to the decrease in the mortality rate of the residents. When the number of healthcare workers per 1,000 population in different regions of Guangdong is used as an indicator of the explanatory variable, the coefficients of the number of healthcare workers per 1,000 population are significantly negative at the 1% level (-3.84, -3.70), indicating that the increase in the

number of healthcare workers per 1,000 population in different regions of Guangdong Province leads to a decrease in the mortality rate of residents in Guangdong. In terms of control variables, the coefficients of disposable income per capita and population density are both significantly negative at the 1% level, indicating that the higher the disposable income per capita, the lower the mortality rate of residents in Guangdong (as shown in Table 5.14).

It should be noted that the R-squared values in our models are relatively high, indicating that a large proportion of the variance in the mortality rate can be explained by the included variables. We have examined the correlation matrix of the independent variables and found that some variables are indeed correlated. However, given the theoretical importance of these variables in explaining health outcomes and their individual significance in the regression results, we have retained them in the models. The high R-squared values reflect the comprehensive impact of multiple factors on residents' health. For example, in a study on the allocation of health resources in the Yangtze River Delta region, it was also found that variables related to health resource allocation showed significant correlations, and the R-squared values were relatively high. This is because the variables included in the model comprehensively captured the factors influencing health resource allocation and utilization in the region (Shen Y, 2022). This indicates that multiple factors jointly influence health outcomes and resource allocation, and the high R-squared values reflect the comprehensive impact of these factors.

Table 5.14 Analysis of the correlation between healthcare resources and residents' health in Guangdong Province (2011-2020)

	Model 1	Model 2	Model 3	Model 4
Hospital beds per 1,000 population	-0.9211*** (-4.28)	-0.9211*** (-4.43)		
Healthcare workers per 1,000 population			-0.5694*** (-3.84)	-0.5694*** (-3.70)
Per capita disposable income	0.0000 (1.20)	0.0000 (1.53)	-0.0001* (-1.80)	-0.0001*** (-1.87)
Population density	-0.0012*** (-3.26)	-0.0012*** (-3.27)	-0.0019*** (-4.09)	-0.0019*** (-3.66)
Urbanization rate	0.0486*** (2.82)	0.0486*** (2.58)	0.0817*** (3.54)	0.0817*** (3.03)
Year controlled or not	Yes	Yes	Yes	Yes
Constant term	4.272*** (7.11)	4.272*** (6.89)	3.422*** (4.65)	3.322*** (4.19)
R-squared	0.8811	0.8811	0.8707	0.8707

Note: Model 1 and Model 2 are estimates using the number of hospital beds per 1,000 population as an indicator to measure the disparity of healthcare resources in different regions of Guangdong Province; Model 3 and Model 4 are estimates using the number of healthcare workers per 1,000 population as an indicator to measure the

disparity of healthcare resources in different regions of Guangdong Province; Model 1 and Model 3 adopt the IV method, and Model 2 and Model 4 adopt the OLS method.

5.3.2 Sensitivity analysis

In order to test the validity of the results, a robustness test is carried out by including the aging rate as a control variable, dividing the sample into two time periods with 2015 as the boundary year, and selecting the number of hospital beds per 1,000 population in different regions of Guangdong Province and the government's healthcare expenditures as the indicators of the explanatory variables. Given that the aging rate is a key factor affecting residents' health, the model first incorporates this indicator as a control variable. The regression results show that the number of hospital beds per 1,000 population is significantly negative at the 5% significance level, but the coefficient of aging rate fails the statistical test. A possible explanation is that only four of the 21 prefecture-level cities in Guangdong Province, namely, Guangzhou, Maoming, Zhanjiang, and Qingyuan, continuously disclose data on the aging rate, while the remaining 17 prefecture-level cities do not provide the relevant information in their statistical yearbooks. This study adopts the aging rate available at the municipal level as a regional alternative indicator, leading to limitations in data completeness. Therefore, in Model 6 and Model 7, this control variable is no longer retained to avoid the interference of measurement error on the estimation results. In 2015, China's healthcare policy and health care system underwent a significant change, as there are significant changes in the statistical yearbooks. We obviously found that the number of healthcare institutions increased significantly or even doubled after 2015, which is mainly due to the fact that primary medical institutions such as township health centers were included in the overall healthcare system in 2016. An important strategic plan to deepen the medical and health care system reform was formulate to establish a new type of health care system. Model 6 and Model 7 are differentiated with the year of 2015 as a watershed on the basis of the original regression model. Model 6 has a time span of 2011 to 2015, and model 7 has a time span of 2016 to 2020. In Model 6, the coefficient of hospital beds per 1,000 population in different regions of Guangdong is significantly negative at the 1% level, and the coefficient of population density in different regions of Guangdong is significantly negative at the 5% level. In Model 7, the coefficient of hospital beds per 1,000 population in different regions of Guangdong is significantly negative at the 10% level, and the coefficients of disposable income per capita and population density are also significantly negative at the 10% level. Model 8 further replaces the explained variable with government healthcare expenditure and the regression results show that its coefficient is significantly negative at the 1% level. In

summary, the sign and significance of the core explanatory variables remain robust under different model settings (see Table 5.15), and the findings are highly reliable.

Table 5.15 Robustness analysis of the correlation between healthcare resources and residents' health in Guangdong (2011-2020)

	(5) Indicator of aging rate included	(6) 2011-2015	(7) 2016-2020	(8) FE, OLS
Hospital beds per 1,000 population	-0.5611** (-1.70)	-1.5101*** (-4.27)	-0.8367 * (-1.91)	
Government healthcare expenditure				-0.1137*** (-3.16)
Aging rate	-0.3811 (-1.12)			-1.7601*** (-2.76)
Per capita disposable income	0.0004* (1.51)	0.0002* (2.12)	-0.0001* (-1.80)	0.0005*** (2.92)
Population density	-0.0013** (-3.024)	-0.0017** (-2.29)	-0.0010* (-1.98)	
Urbanization rate	0.0570 (2.72)	0.0815*** (3.41)	0.0304 (3.54)	-0.0608** (-2.30)
Year controlled or not	Yes	Yes	Yes	Yes
Constant term	8.346 (2.27)	2.016 (2.34)	5.319*** (7.05)	27.566*** (3.70)
R-squared	0.8850	0.8854	0.8715	0.9194

5.4 Results of literature content analysis

5.4.1 Literature content analysis based on evaluation methods

According to Figure 5.4 and Figure 5.5, most of the evaluation indicators used in this study are included in the coded literature, and the least frequently used indicator is the healthcare institution (73.7%), which may be related to the fact that the research topic of some literature is healthcare human resources. Among the evaluation methods, the Gini coefficient, Theil index and Lorenz curve are the most frequently used to evaluate the allocation of healthcare resources, while cluster analysis is the least frequently used evaluation method, which also provides some reference for the rationality and feasibility of this study.

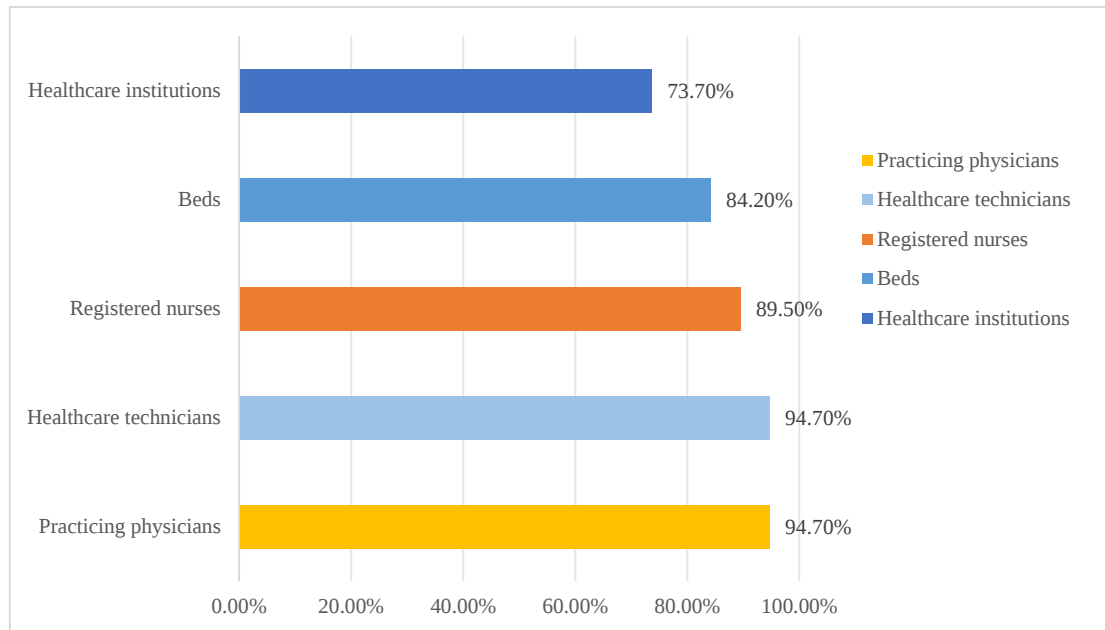


Figure 5.4 Literature content analysis

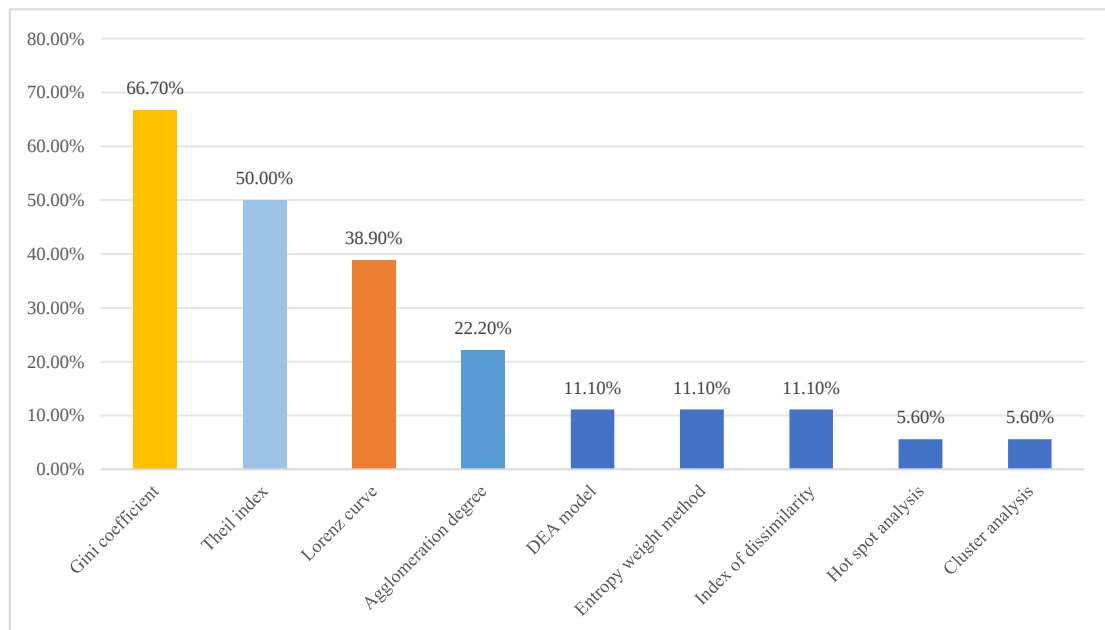


Figure 5.5 Evaluation indicator code results

5.4.2 Literature content analysis based on equity and changing trends

The literature shows that as for the regional resource allocation, there are huge regional differences between provinces and municipalities. It is mentioned that the difference in healthcare resource allocation is mainly reflected between large cities and small cities, and this phenomenon may be due to the inconsistency of economic development. As for the allocation of the total amount of resources, there is also huge difference between hardware and software in each place, which is described as hardware resources exceeding software resources. In other

words, the total amount of medical and nursing personnel and healthcare technicians is insufficient, and cannot meet the demand for healthcare institutions and beds, which is close to the status quo of healthcare resource allocation in Guangdong Province in this study. In the article *Equity analysis of healthcare resources in Liaoning Province based on the Gini coefficient and the Lorenz curve*, based on the 2011 Liaoning Provincial Statistical Yearbook, the researchers conclude that although the Gini coefficients of various types of health resources are between 0.3 and 0.4, health resource allocation in Liaoning is still relatively equitable. However, this article has some limitations because it only selects data from a single year for analysis.

By analyzing the trend of each piece of literature, it can be concluded that in recent years, most of the healthcare resource allocation in China's provinces and cities have shown a growing trend, but there are also exceptions in some regions. For example, according to the article *Analysis of spatial fairness of healthcare resource supply to professional public health institutions in Xinjiang*, the number of practicing (assistant) physicians has a fluctuating downward trend, the number of health technicians rises and then declines, and the number of public healthcare institutions shows a year-on-year declining trend. According to the article *Research on the current situation and equity of healthcare resource allocation in Guangxi from 2015 to 2017*, the number of healthcare institutions per 1,000 population shows a declining trend. This study shows that the change of healthcare resources in Guangdong Province presents a rising trend year by year, which is consistent with the trend in most provinces and cities across China.

5.4.3 Literature content analysis based on policy content

The study shows that most of the recommendations belong to supply-based policies, with talent training (23.08%) and capital investment (18.45%) accounting for the highest proportion, while cooperation mode (20.00%) also accounts for a relatively high proportion in the demand-based policies. It indicates that in the construction of healthcare resources in China, there is a lack of financial investment and talent training, and in less economically developed cities, the fairness is relatively poor. In addition, researchers have also proposed the cooperation between large cities and small cities to form medical alliances and spread resources and talents from large cities to small cities.

5.5 Integrated Analysis of Questionnaire Data and Interview Findings

To further enhance the comprehensiveness and explanatory power of the research conclusions, this study conducts an integrated analysis of questionnaire survey results and interview findings after presenting them separately. Overall, the quantitative and qualitative results demonstrate strong consistency in their core findings, while also providing complementary insights at the interpretive level. The questionnaire results indicate that there are notable regional differences among residents in Guangdong Province in terms of accessibility to medical services, experiences in resource utilization, health perception, and satisfaction with healthcare services. In particular, disparities are more pronounced in primary healthcare service provision, accessibility to high-quality medical resources, and support for chronic disease management. The interview findings further corroborate these results. Many respondents pointed out that the Pearl River Delta region has clear advantages in terms of the density of medical institutions, equipment allocation, human resource reserves, and specialized service capacity. In contrast, some areas in eastern, western, and northern Guangdong still face challenges such as insufficient high-quality medical resources, loss of grassroots medical personnel, lagging equipment updates, and a relatively high incidence of cross-regional healthcare-seeking behavior. This suggests that the regional disparities reflected in the questionnaire data have a solid empirical basis, rather than being limited to residents' subjective perceptions.

At the same time, the integration of the two types of data contributes to a deeper understanding of the mechanisms underlying regional imbalances in medical resource allocation. The questionnaire survey effectively addresses the questions of whether disparities exist and in which aspects they are most evident, while the interview data further explain why these disparities arise. For example, residents in some regions rated the capacity of primary healthcare services relatively low; the interviews reveal that this is closely related to factors such as the shortage of highly qualified medical personnel in primary institutions, limited training opportunities, relatively weak medical equipment, and the inadequate implementation of hierarchical diagnosis and treatment systems as well as two-way referral mechanisms. This indicates that regional disparities in medical resource allocation are not only reflected in quantitative imbalances but also in differences in quality and service capacity. The questionnaire data present the outcome characteristics of resource inequality from the residents' perspective, whereas the interview data uncover the institutional, structural, and practical causes from the perspectives of government administrators, healthcare managers, and frontline medical staff.

In summary, the questionnaire survey and interview findings mutually corroborate and complement each other, jointly demonstrating that significant regional disparities persist in medical resource allocation and its health impacts across Guangdong Province. Quantitative analysis enhances the generalizability and measurability of the findings, while qualitative analysis deepens the understanding of real-world issues. Through the integration of these two types of data, this study not only provides a more comprehensive depiction of the manifestations of imbalanced medical resource allocation but also reveals the underlying pathways through which such imbalances affect residents' health and healthcare experiences, thereby highlighting the value of mixed-methods research in this study.

5.6 Qualitative interviews on health resource allocation: multi-subject perceptions and countermeasure suggestions

The qualitative analysis of interview transcripts yielded rich, nuanced insights into the perceived causes, consequences, and potential solutions to healthcare resource disparities in Guangdong Province. The findings are organized according to the three key stakeholder groups interviewed, presenting a multi-faceted perspective on the problem. The following sections detail the predominant themes that emerged from these in-depth conversations, highlighting both the consensus views and the unique challenges identified by each group.

5.6.1 Interviews on health administrative personnel

Health administrative personnel provided a macro-level, policy-oriented perspective on the challenges of resource allocation. Their responses consistently highlighted the tension between the ideals of equitable planning and the practical constraints of fiscal capacity, demographic pressures, and historical legacies of regional development. The interview data revealed three central themes in their policymaking and management approach.

(1) Regional health planning

Interview results show that health administrative personnel mainly consider factors such as population density, changes in the disease spectrum and the efficiency of existing resource utilization when formulating regional health planning. There is a significant gap in the distribution of health resources between the PRD region and other regions, which is mainly reflected in the uneven distribution of medical equipment and human resources. To narrow the gap, measures have been taken to increase financial investment and guide resources to be

allocated to less developed regions. In the dynamic adjustment of health resource allocation, priority has been given to the medical service needs of the aging population and migrant workers, and structural contradictions have been addressed through the establishment of special funds and optimization of resource allocation strategies. Administrative personnel noted that while population density is a primary driver for resource distribution formulas, this often perpetuates the advantage of the densely populated PRD. A significant challenge cited was the "lag effect," where planning cycles and infrastructure projects cannot keep pace with the rapid internal migration and urbanization trends within the province.

(2) Performance assessment of resource allocation

The current performance assessment criteria mainly include resource utilization efficiency, service accessibility and improvement of residents' health. A correlation model between health outcome indicators (such as mortality rate and chronic disease prevalence rate) and resource allocation (such as number of beds per 1,000 population and number of healthcare workers) has been established in the assessment system. According to the assessment results, geographical differences and imbalance in human and material resources are the most prominent problems, and measures have been taken to increase investment on primary healthcare institutions and optimize resource allocation.

(3) Challenges in resource allocation

Under the framework of collaborative healthcare development in the Guangdong-Hong Kong-Macao Greater Bay Area, the existing resource allocation mechanism faces challenges in information sharing and policy coordination to adapt to the demands for cross-border healthcare services. To address these challenges, inter-regional cooperation has been strengthened and information platforms have been established. Priority will be given to improving the service capacity of primary healthcare institutions if an additional 10% of the health budget is granted. This prioritization reflects administrators' consensus, especially for aging populations. Resource allocation would specifically target diagnostic capacity expansion and chronic disease management infrastructure to address identified service gaps in hypertension and diabetes control. Compared with the Yangtze River Delta region, Guangdong has the advantage of policy flexibility in resource allocation mechanisms, but there is still room for improvement in resource integration. The comparative advantage in policy innovation is counterbalanced by implementation fragmentation across the province's four economic zones. Unlike the Yangtze Delta's centralized resource command structure, Guangdong's system requires strengthened coordination mechanisms for medical equipment pooling, specialty workforce deployment, and

emergency response coordination to fully leverage its diverse healthcare assets across metropolitan and rural settings.

5.6.2 Interviews on healthcare institution administrators

Healthcare institution administrators focused on the operational and managerial challenges of functioning within the existing resource allocation framework. Their responses highlighted the daily trade-offs and strategic decisions required to deliver services amidst constraints, offering a ground-level view of how macro-level policies manifest in institutional practice. The interviews revealed three predominant areas of concern that dominate administrative agendas.

(1) Equipment deployment and brain drain

Hospitals mainly consider the urgency of equipment needs, cost-effectiveness and patient flow in terms of equipment deployment. In recent years, brain drain has been mainly concentrated in departments such as internal medicine and surgery for factors including salary, working environment and career development opportunities. To cope with these problems, hospitals have taken measures to raise salaries, improve the working environment and provide career development support, and some hospitals have achieved initial results. While measures like salary increases and improved working conditions have shown some success in retaining staff, administrators expressed concern that these are often insufficient to address the root causes of brain drain. The fundamental attraction of larger, urban hospitals—encompassing superior professional development opportunities, access to specialized expertise, advanced research environments, and often better educational facilities for employees' children—creates a powerful pull factor.

(2) Construction of primary healthcare institutions

Primary healthcare institutions face the problems of lack of funds and insufficient technical support in their construction in a standardized manner. After hardware facilities meet the standards, operation and maintenance funds are mainly solved through government subsidies and medical service charges. The collaborative relationship between primary healthcare institutions and higher-level hospitals faces difficulties in information sharing and resource coordination in the development of medical alliances, and it is recommended that the collaborative mechanism can be improved by strengthening IT application and policy support. To enhance service capacity, it is suggested to promote service quality, improve patient satisfaction, advance medical technology.

(3) Medical insurance settlement and health information literacy

As for cross-city medical insurance settlement, hospitals face problems of poor information exchange and policy differences, which can be solved by strengthening information system construction and policy coordination. To improve patient satisfaction, hospitals have strengthened training and optimized processes. As for improvement of residents' health information literacy, hospitals have carried out health education and community cooperation, which proves to be effective, but still needs further support from government policies and the community.

5.6.3 Interviews on clinical medical personnel

Clinical medical personnel provided a frontline, operational perspective on the tangible consequences of resource allocation disparities. Their narratives offered granular insights into daily clinical practice, patient care quality, and professional satisfaction. The interviews surfaced three critical dimensions of their experience working within the existing healthcare ecosystem.

(1) Impact of resource shortage on diagnosis and treatment

When attending to patients referred across regions, clinical medical personnel have observed typical problems in diagnosis and treatment due to differences in resource allocation, such as insufficient equipment, shortage of medicines and lack of specialized staff. These problems can be resolved through temporary deployment of resources and cross-regional collaboration.

(2) Doctor-patient relationship and technology application

In the application of new technologies such as telemedicine, medical staff encounter challenges such as technical barriers, low patient trust and operational complexity. Patients' acceptance of telemedicine has been gradually increased. New technologies have positive effects in improving the doctor-patient relationship, but there are also negative effects such as technological dependence. To improve the quality of medical services, it is recommended that technical training, equipment updating and policy support should be strengthened.

(3) Views on policies and systems

Healthcare professionals believe that the current health resource allocation policies and systems have problems of uneven resource distribution, insufficient funding and inadequate policy implementation. It is recommended to increase investment on primary healthcare, optimize the resource allocation mechanism, and strengthen talent training. They highly recognize the actual effect of the construction of county-level medical centers under the "100

Hundred Counties Project”, believing that remarkable results have been achieved in terms of resource coverage, service accessibility and resident health improvement.

5.7 Analysis of healthcare resource allocation and residents’ health in Guangdong through basic questionnaire

A total of 3,334 questionnaires were distributed in this study, of which 3,000 were returned. All returned questionnaires were valid, resulting in an effective sample size of 3,000 and an effective response rate of approximately 90.0%. The actual response rate exceeded expectations, ultimately achieving an effective recovery rate of about 90.0%.

5.7.1 Descriptive statistical analysis

5.7.1.1 Analysis results of the current status of health resource allocation

As can be seen from Table 5.16, there are significant differences in the performance of different regions in Guangdong Province in the three indicators: medical equipment, government funding and healthcare personnel satisfaction. The satisfactions of the PRD region are significantly higher than those of the other regions in all indicators, with satisfaction with medical equipment being 82.4%, satisfaction with government funding being 75.6%, and satisfaction with healthcare personnel being 78.9%. In contrast, northern Guangdong has the lowest satisfaction levels, with the satisfactions being 47.3%, 54.8% and 51.2% respectively. The satisfaction levels in eastern and western Guangdong are in between, but lower than those in the PRD region in general. Significance test results show that the F values of the three indicators are 36.82, 24.15 and 41.73 respectively, with p values all less than 0.001, indicating that the differences in satisfaction among regions are highly statistically significant.

Table 5.16 Comparison of satisfaction with health services among regions in Guangdong Province

Indicator	PRD	Eastern Guangdong	Western Guangdong	Northern Guangdong	Significance test (χ^2/p)
Satisfaction with medical equipment (%)	82.4	65.2	58.7	47.3	$\chi^2=36.82, p<0.001$
Satisfaction with government funding (%)	75.6	68.4	62.1	54.8	$\chi^2=24.15, p<0.001$
Satisfaction with healthcare personnel (%)	78.9	63.7	59.5	51.2	$\chi^2=41.73, p<0.001$

5.7.1.2 Prevalence of chronic diseases

There are significant differences in the prevalence of five chronic diseases (malignant tumor, hypertension, rheumatoid arthritis, chronic obstructive pulmonary disease and diabetes) among different regions in Guangdong Province. The prevalence of chronic diseases is generally high in northern Guangdong, with the prevalence of malignant tumors being 13%, significantly higher than that in the Pearl River Delta (7%), eastern Guangdong (8%) and western Guangdong (6%). The prevalence of hypertension in northern Guangdong is 8%, which is also higher than that in other regions of Guangdong. The prevalence of rheumatoid arthritis is also high in northern Guangdong (6%), but it is basically the same with the prevalence in other regions. The prevalence of chronic obstructive pulmonary disease (COPD) is 10% in both eastern and northern Guangdong, significantly higher than that in the Pearl River Delta (4%). The prevalence of diabetes is highest in northern Guangdong (12%) and lowest in the PRD (5%). Significance tests show that the chi-square values of the prevalence rates of all chronic diseases are greater than the critical values, and the p values are all less than 0.05, indicating that the differences in the prevalence rates of chronic diseases among the regions are statistically significant. (See Figure 5.6 and Table 5.17).

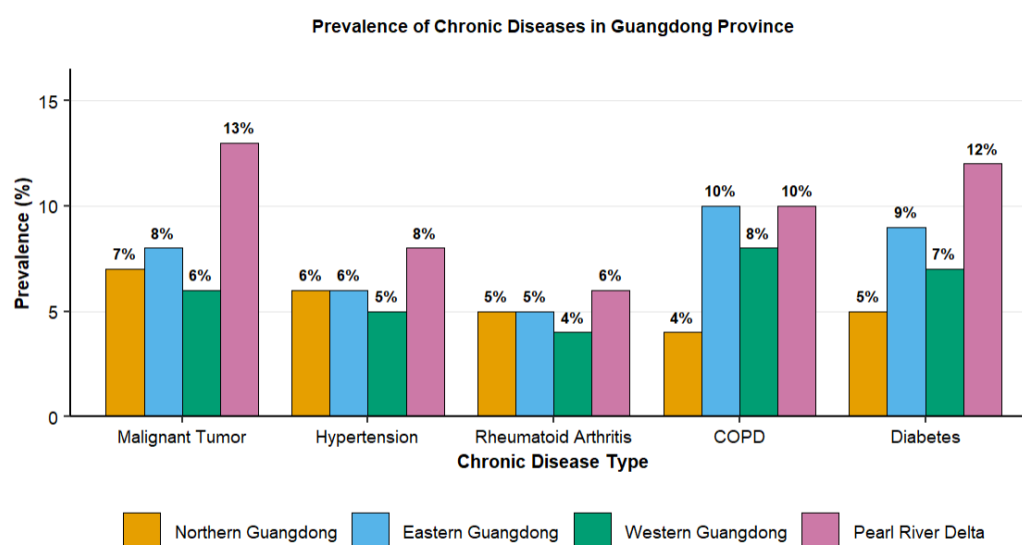


Figure 5.6 Comparison of the prevalence of chronic diseases among regions in Guangdong Province

Table 5.17 Comparison of the prevalence of chronic diseases among regions in Guangdong Province

Types of chronic diseases	PRD	Eastern Guangdong	Western Guangdong	Northern Guangdong	Significance test (χ^2/p)
Prevalence of malignant tumors (%)	7	8	6	13	$\chi^2=12.45, p<0.05$
Prevalence of hypertension (%)	6	6	5	8	$\chi^2=6.23, p<0.05$

Types of chronic diseases	PRD	Eastern Guangdong	Western Guangdong	Northern Guangdong	Significance test (χ^2/p)
Prevalence of rheumatoid arthritis (%)	5	5	4	6	$\chi^2=4.87, p<0.05$
Prevalence of COPD (%)	4	10	8	10	$\chi^2=9.12, p<0.05$
Prevalence of diabetes (%)	5	9	7	12	$\chi^2=15.34, p<0.05$

5.7.1.3 Lifestyle

One-way ANOVA shows that there are regional differences in the frequency of physical activity ($F=15.34, p<0.001$). The weekly frequency of physical activity of moderate intensity or above is higher among residents in the PRD region ($M=3.2, SD=1.1$) than those in eastern Guangdong ($M=2.5, SD=1.3$), western Guangdong ($M=2.3, SD=1.4$) and northern Guangdong ($M=2.0, SD=1.5$). Smoking rate and drinking rate show an inverse trend, with the figures being 18.6% and 22.4% respectively in the PRD, which are significantly lower than those in other regions ($p<0.05$, see Table 5.18).

Table 5.18 Comparison of lifestyles among different regions in Guangdong Province

Variable	PRD	Eastern Guangdong	Western Guangdong	Northern Guangdong	F/χ^2	p
Physical activity (Times/week)	3.2 ± 1.1	2.5 ± 1.3	2.3 ± 1.4	2.0 ± 1.5	15.34	<0.001
Smoking rate (%)	18.6	31.5	28.9	29.3	8.34	<0.05
Drinking rate (%)	22.4	35.2	33.7	34.8	6.69	<0.05

5.7.1.4 Blood pressure, blood glucose, and blood lipids

According to Table 5.19, there are significant differences in the normalization rates of blood pressure, blood glucose and blood lipids among different regions in Guangdong. The PRD region has the highest blood pressure normalization rate (75.0%), which is significantly higher than that of eastern Guangdong (60.0%), western Guangdong (55.0%) and northern Guangdong (50.0%). The normalization rate of blood glucose is also higher in the PRD region (68.2%) than in eastern Guangdong (56.0%), western Guangdong (54.3%) and northern Guangdong (50.5%), and the differences are statistically significant.

Table 5.19 Comparison of blood pressure, blood glucose, and blood lipids among different regions in Guangdong Province

Variable	PRD	Eastern Guangdong	Western Guangdong	Northern Guangdong	χ^2	p
Blood pressure normalization rate (%)	75.0	60.0	55.0	50.0	24.18	<0.001
Blood glucose normalization rate (%)	68.2	56.0	54.3	50.5	13.14	<0.05
Blood lipids	63.7	51.2	49.8	47.6	14.67	<0.05

normalization rate (%)

5.7.1.5 Health literacy level

There are significant regional differences in scores of health literacy ($F=28.91$, $p<0.001$). The PRD region has the highest mean score ($M=7.8$, $SD=1.2$), which is significantly higher than that of eastern Guangdong ($M=6.5$, $SD=1.5$), western Guangdong ($M=6.2$, $SD=1.6$) and northern Guangdong ($M=6.0$, $SD=1.8$) (see Figure 5.7).

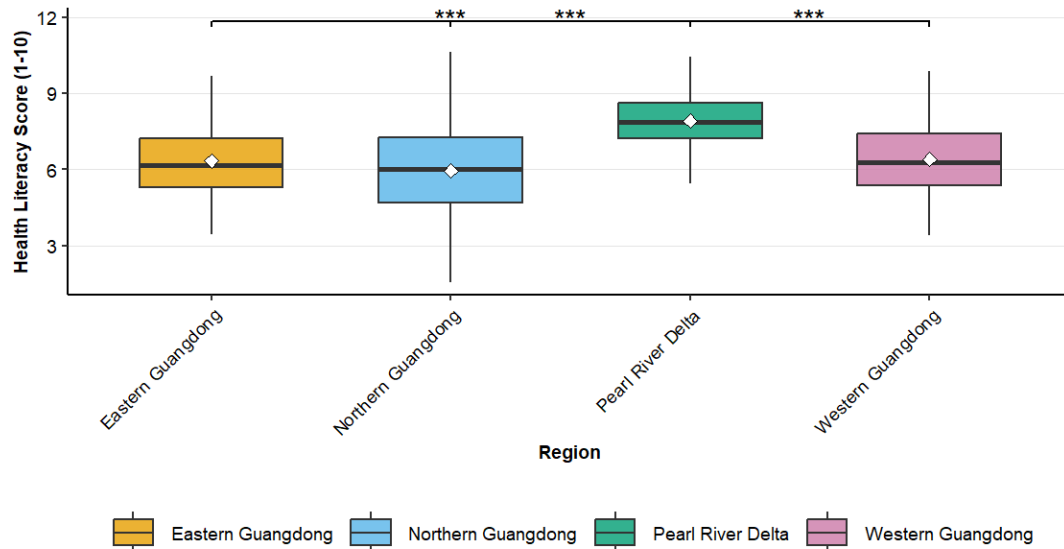


Figure 5.7 Comparison of health literacy scores among different regions in Guangdong Province

5.7.2 Correlation analysis

5.7.2.1 Correlation between chronic diseases and lifestyle

As shown in Table 5.20, correlation analysis indicates that smoking behavior has a moderately positive correlation with the prevalence of lung cancer ($r=0.45$, $p<0.001$); drinking behavior has a significantly positive correlation with the prevalence of liver disease ($r=0.38$, $p=0.002$); and frequency of physical activity has a strongly negative correlation with the prevalence of chronic diseases ($r=-0.52$, $p<0.001$).

Table 5.20 Analysis of the correlation between the prevalence of chronic diseases and lifestyle factors

Lifestyle factors	Corresponding chronic diseases	Correlation coefficient (r)	p
Frequency of physical activity	Chronic disease prevalence	-0.52	<0.001
Smoking behavior	Lung cancer prevalence	0.45	<0.001
Drinking behavior	Liver cancer prevalence	0.38	0.002

5.7.3 Comparative analysis by subgroups

5.7.3.1 Comparison of health status and lifestyle between residents with different degrees of education

As shown in Supplemental Table a.20, the group with higher degree of education is significantly better than the group with lower degree of education in terms of health behaviors and lifestyles. The average number of physical activities performed by residents in group with higher degree of education is 3.2 times per week, which is significantly higher than that of the group with lower degree of education, which is 1.8 times ($t=4.23$, $p<0.001$). The rate of regular physical examination is 72.2% in the group with higher degree of education, which is significantly higher than 59.3% in the group with lower degree of education ($\chi^2=18.45$, $p<0.001$). In addition, the smoking rate (13.6%) is significantly lower in group with higher degree of education than group with lower degree of education (35.5%) ($\chi^2=12.34$, $p<0.001$), and the drinking rate is also significantly lower.

5.7.3.2 Comparison of health status and lifestyle between residents with different geographic locations

The results show that there are significant differences in the health behaviors and lifestyles between residents of different geographic locations. Residents in the downtown area group perform physical activities 3.5 times per week on average, which is significantly higher than 2.8 times in the suburb group and 2.0 times in the urban-rural fringe group ($F=12.45$, $p<0.001$). The rate of regular physical examination is 78.5% in the downtown area group, which is significantly higher than 65.2% in the suburb group and 52.3% in the urban-rural fringe group ($\chi^2=18.34$, $p<0.001$). Similar trends are observed for smoking rate and drinking rate, with both smoking (12.0%) and drinking rates (25.0%) in the downtown area group being significantly lower than those in the suburb group (20.5% and 30.0%) and urban-rural fringe group (30.2% and 35.0%). The difference in smoking rates is highly significant ($\chi^2=15.67$, $p<0.001$), and difference in drinking rates is also statistically significant ($\chi^2=6.78$, $p<0.05$) (see Supplemental Table a.21).

Comprehensive questionnaire analysis shows that there are significant differences in the health status of residents in different regions of Guangdong Province. Residents in the PRD region have better performance in terms of prevalence of chronic diseases, lifestyle, control of blood pressure, blood glucose and blood lipids, and health literacy, while residents in the eastern, western and northern Guangdong have relatively poor performance in these areas. This may be

related to the level of economic development of the regions, distribution of medical resources and health awareness of the residents. It is recommended that health education and medical resource allocation should be strengthened in the eastern, western, and northern Guangdong to improve residents' health literacy and accessibility to medical services, so as to promote the balanced development of residents' health status in Guangdong.

Chapter 6: Discussion

6.1 Analyzing Health Resource Allocation Equity in Guangdong: A Theil Index Perspective

Based on the analysis of the Theil index of the number of healthcare institutions, beds, and healthcare personnel from 2011 to 2020, the Theil indexes of each healthcare resource under the population dimension are significantly smaller than those under the geographic dimension. This indicates that the equity of healthcare resources under the population dimension is better than that under the geographic dimension. To further clarify this contrast, the population-based perspective emphasizes parity in service capacity relative to demand, whereas the geographic perspective captures the spatial frictions that mediate actual access. By jointly considering both dimensions, the analysis avoids overstating equity on the basis of demographic ratios alone and highlights the role of spatial dispersion in shaping realized access. This implies that when resources are distributed relative to the population size, the allocation appears more balanced, as the per capita availability of institutions, beds, and healthcare personnel aligns more closely across regions. In contrast, when geographic distribution is considered, vast disparities become more evident, particularly due to the large land areas with sparse populations in northern and western Guangdong, where accessibility is hindered by long distances and insufficient healthcare infrastructure. In these areas, travel time to the nearest facility often exceeds routine thresholds for timely care, and limited emergency coverage reduces the effectiveness of referral pathways, thereby magnifying treatment delays. This contrast underscores that the perception of equity can vary substantially depending on the measurement dimension applied. Accordingly, interpreting distributional indicators without explicit reference to their underlying dimension may lead to divergent conclusions about fairness and policy priorities. This finding is consistent with the result of research on the Theil index of equity in healthcare resource allocation in Guangdong that inter-regional disparity is the most important factor contributing to the inequitable allocation of healthcare resources in Guangdong (Du & Xu, 2015). Such consistency strengthens the external validity of the present results and suggests that inter-regional segmentation remains a primary locus of allocative inefficiency within the province. The reason for this phenomenon may be that China has long been measuring the equity of

healthcare resources by the standard of resource allocation per 1,000 population, and the relevant departments plan the allocation of resources in an indicator-oriented manner, possibly due to the lack of consideration of the impact of factors such as geographic location and the radius of health services on equity. Such a measurement standard, while practical for demographic balance, often masks the unequal distribution that arises from geographic barriers. For example, although two regions may have similar physician-to-population ratios, residents in remote mountainous areas still face significant obstacles in reaching healthcare facilities, leading to delays in treatment and reduced accessibility. This highlights that planning guided solely by population-based indicators may fail to capture the lived realities of residents in geographically disadvantaged areas. From a planning standpoint, this implies that population-normalized quotas should be complemented with distance-sensitive thresholds and service-radius considerations when setting regional benchmarks. The Gini coefficients of various types of healthcare resources in Guangdong under the population dimension are all in a relatively balanced and optimal state, while those under the geographic dimension are mostly stabilized at the normal state. Further supporting this interpretation, the decomposition of Theil index values revealed that inter-regional disparities contributed more prominently to overall inequity than intra-regional variations. This indicates that while internal distribution within each sub-region may not show extreme imbalance, the gaps between the Pearl River Delta and other regions remain the dominant driver of inequity. The prominence of between-region components also indicates that marginal improvements within individual sub-regions may yield limited province-wide gains unless accompanied by cross-regional rebalancing. Such a pattern is consistent with the structural concentration of high-quality medical institutions and professionals in urban agglomerations such as Guangzhou and Shenzhen. It suggests that geographic location should be fully considered in health resource planning, especially the allocation of health resources in the western and mountainous regions of Guangdong province. The impact of geographic location on the equity of health resources can be reduced by appropriately adjusting the radius of health services, increasing the investment of health resources in geographically remote areas, and upgrading the level of health services in remote areas. In practice, this would require not only the physical construction of additional facilities but also the strategic deployment of skilled health professionals, since hardware improvements without adequate human resources are unlikely to translate into substantial service capacity gains. Moreover, improving transport infrastructure and referral networks can complement health resource investments, ensuring that residents in remote regions can access timely and efficient medical services. Only through a comprehensive approach that addresses both the

quantity and quality of resources can the long-standing geographic inequities be effectively alleviated.

The calculation results of the Theil index show that there are significant differences in the allocation of healthcare resources across regions in Guangdong Province. As seen from the healthcare resource agglomeration, the health resource agglomeration degrees of the PRD region and eastern Guangdong are both greater than 1 and have been increasing year by year, indicating that these two regions have relatively good allocation of health resources and high healthcare service capacity. In operational terms, differentiated strategies entail calibrating inputs to local service loads, stabilizing workforce retention through targeted incentives, and enhancing inter-regional coordination to alleviate bottlenecks. In contrast, in western Guangdong and the mountainous region, the agglomeration degrees of healthcare resources are much less than 1 and the geographic accessibility of healthcare resources is not improved, indicating that the allocation of healthcare resources in western Guangdong and the mountainous region is relatively poor and the capacity of healthcare services needs to be improved. This persistent insufficiency suggests that the structural barriers in these regions are not temporary but long-standing. Limited infrastructure, coupled with the outflow of healthcare professionals to more developed urban centers, further exacerbates the problem. As a result, residents in these areas are not only disadvantaged in terms of resource accessibility but also experience delays in receiving timely and effective treatment. Such systemic gaps highlight the urgency of adopting differentiated strategies that address the specific challenges faced by the less developed regions of Guangdong. This conclusion is consistent with the research finding of Yu and Chen (2023) that the allocation of healthcare resources and the equity of healthcare in Guangdong province present a pattern of distribution from high to low in the order of PRD region, eastern Guangdong, western Guangdong, and the mountainous region. It is also pointed out that the level of healthcare resource agglomeration in Guangdong province is characterized by polarization and regional disparity (Gong et al., 2017).

There are significant differences in the agglomeration of healthcare resource allocation within Guangdong, with the largest gap between the mountainous region and other regions, followed by western Guangdong. The PRD region shows a relative surplus of healthcare resources and is able to satisfy public demands. However, judging from the Lorenz curve results, healthcare resource allocation in Guangdong is not yet balanced, and the equity of healthcare personnel is poor. The imbalance in healthcare personnel is particularly critical, as human resources serve as the fundamental driver of medical service delivery. Even if facilities and equipment are available, a shortage of qualified healthcare professionals significantly

undermines the actual service capacity. This discrepancy between material inputs and human resources not only weakens the resilience of the healthcare system but also restricts the province's ability to respond effectively to public health emergencies. Therefore, the problem of healthcare personnel equity constitutes a bottleneck in the pursuit of balanced and efficient healthcare development. Sustained improvements therefore depend on aligning facility expansion with parallel growth in qualified personnel, particularly in general practice and essential specialties. Similarly, even with a high level of healthcare human resource allocation, Beijing also faces the problem of unequal regional resource allocation. It is found that there is an obvious imbalance in the allocation of healthcare resources in each functional area of Beijing, and health resource allocation in the capital functional core area and the downtown area is much better than that in other areas (Dong et al., 2023). Bao et al. (2023) conducted a study on the current status of healthcare resource allocation in the Chengdu-Chongqing Economic Circle from 2015 to 2019, and they also found significant differences in healthcare resource allocation between regions in the Circle. The equity of allocation by economy and population is relatively good, while equity of allocation by geography is severely uneven, and the demographic and geographic accessibility of healthcare human resource is relatively poor. It is similar to healthcare resource allocation in Guangdong. For the western and mountainous regions of Guangdong with low degree of agglomeration, it is necessary to strengthen healthcare resource allocation planning, increase investment in health facilities and human resources, and improve the capacity of healthcare services. The distribution of healthcare resources should also be appropriately adjusted to avoid excess and wastage of healthcare resources in the PRD region, and part of the resources should be directed to eastern Guangdong and the mountainous region where the degree of agglomeration is relatively low. Such redistribution does not necessarily imply reducing the overall service quality of the PRD region but rather emphasizes the importance of more rational cross-regional coordination. By alleviating the excessive concentration of resources in highly developed areas, Guangdong can achieve a more sustainable allocation pattern, one that both preserves the advanced medical capacity of the PRD and strengthens the weak healthcare foundation of less developed areas. This balanced development approach would allow the province to move closer to realizing health equity across all regions. It is also necessary to increase the investment in healthcare institution beds, healthcare technicians, healthcare workers, and practicing (assistant) physicians in each region, and at the same time, improve the equity of healthcare resource allocation according to the population. In conclusion, to solve the problem of disparity in healthcare resource allocation equity in Guangdong, a comprehensive planning is needed from the perspective of the whole

province.

In addition, this study analyzes the efficiency of health resource input and output in Guangdong from 2011 to 2020 using the data envelopment analysis (DEA) model. The results show that the mean value of health resource allocation efficiency in Guangdong during the sample period does not reach DEA efficiency and the fluctuation is significant. From the perspective of pure technical efficiency, the performance of Guangdong province is relatively good in terms of the level of fund management of healthcare expenditure and per capita disposable healthcare expenditure, as well as the rationality of healthcare resource allocation, but there is still room for improvement. As for scale efficiency, it is comparable to pure technical efficiency in terms of the influence on overall efficiency. It indicates that Guangdong province still has the problem of low overall technical efficiency in the utilization and management of healthcare resources, and there is much room for improvement between the input and output of healthcare resources in Guangdong. The mean values of both pure technical efficiency and scale efficiency do not reach 1, indicating that there is room for optimization of resource allocation. The results of the DEA analysis further imply that the inefficiencies observed are not simply a matter of inadequate inputs but also stem from suboptimal utilization of existing resources. For example, overlapping investments in certain urban areas may create redundancies, while insufficient coordination in rural areas results in underuse of scarce facilities. These inefficiencies ultimately reduce the return on healthcare investment and hinder the province's ability to maximize health outcomes within the existing fiscal framework. Addressing this requires not only expanding resources but also improving management systems, optimizing referral mechanisms, and enhancing inter-institutional collaboration. At the same time, benchmarking efficiency frontiers across comparable cities can identify scale mismatches and managerial slack, guiding incremental adjustments in service portfolios. Therefore, it is necessary for Guangdong province to optimize the allocation of resources in each region, improve the management level of healthcare resources in each region, and appropriately expand the scale of healthcare services to improve service quality and efficiency. However, this is slightly different from the results of Guo et al. (2023).

The results of the entropy weight method show that the number of healthcare workers per 1,000 population has the greatest weight from 2011 to 2020. In other words, its contribution to the allocation of healthcare resources is the greatest and provides the most amount of information. On the other hand, the number of healthcare institutions has the smallest weight, namely, its contribution to the allocation of healthcare resources is the smallest. This is consistent with the findings of Cheng and Ruan (2023). Therefore, the number of healthcare

workers per 1,000 population plays a crucial role in the allocation of healthcare resources in Guangdong province. It suggests that it is necessary to strengthen the training and allocation of healthcare human resources to ensure an adequate supply of healthcare workers to meet the people's healthcare needs. Meanwhile, although the number of healthcare institutions has a relatively small impact on resource allocation, it is still an important factor that needs attention and improvement. This is because the presence of healthcare institutions, even when limited in scale, plays a pivotal role in ensuring the basic accessibility of services. For many residents in remote areas, the proximity of a healthcare institution—regardless of its size—can determine whether they seek timely medical treatment. Therefore, while human resources remain the primary determinant of healthcare equity, strengthening the distribution and functionality of healthcare institutions continues to be a necessary condition for improving service accessibility and equity across the province. In summary, in order to optimize the allocation of healthcare resources in Guangdong province, it is recommended to focus on increasing the number of healthcare professionals and improving the operational efficiency of healthcare institutions. Prioritizing workforce deployment in shortage areas, coupled with incremental upgrades to basic institutional functions, can generate measurable gains in access without imposing abrupt disruptions on high-capacity regions. This initiative can help to improve the accessibility and quality of healthcare services in Guangdong.

6.2 Multidimensional Health Impacts of Unequal Resource Allocation in Guangdong Province

6.2.1 Health Impact of Healthcare Resource Inequality in Guangdong

To address the question on the impact of unequal resource allocation on residents' health in Guangdong province, this study employed semi-structured in-depth interviews with 16 health administrators, 48 heads of primary healthcare institutions, and 96 clinical staff. The interviewees highlighted that in regions with scarce healthcare resources, residents often face difficulties in accessing timely and quality healthcare services, leading to delayed diagnoses and treatments, and ultimately resulting in poorer health outcomes. These delays often force patients to make repeated visits across different healthcare institutions, which not only increases their financial burden but also places additional strain on their families. Moreover, the psychological stress associated with prolonged illness and uncertainty regarding treatment further deteriorates the overall well-being of residents in resource-limited areas. This delay in

diagnosis and treatment not only exacerbates the severity of diseases but also increases the chances of complications and long-term health problems. In some cases, the lack of timely medical intervention in under-resourced areas may lead to irreversible health consequences, which could have been preventable if the healthcare services were more accessible. Residents in these regions often resort to self-medication or traditional remedies, which further delays professional medical intervention and worsens their overall health condition. Therefore, the health disparities that arise from unequal resource allocation are not only a reflection of service availability but also a manifestation of the direct impact on individuals' well-being over time. Furthermore, the uneven distribution of healthcare resources also affects the quality of healthcare services. A study of the correlation between healthcare resources and health shows that widening gaps in the number of healthcare technicians per 1,000 population or the number of beds per 1,000 population in healthcare institutions across different regions of Guangdong province can significantly lead to higher mortality rates among residents. This indicates that areas with substantial healthcare resource disparities have lower health levels compared to regions with abundant resources. This finding is corroborated by existing studies. Similar findings have been observed in various regions of China, where the resource gap between urban and rural areas often translates to a stark difference in health outcomes. In cities with better healthcare facilities, such as Beijing and Shanghai, residents tend to have a longer life expectancy and lower mortality rates compared to those in rural or less developed regions. In rural regions, the shortage of specialized healthcare providers means that even when basic healthcare services are available, residents often lack access to advanced medical interventions. This structural disadvantage leads to an accumulation of untreated or poorly managed chronic conditions, which over time translates into substantial gaps in health status between rural and urban populations. The inequitable distribution of healthcare resources often correlates with a lower quality of life for the residents in under-resourced regions, who are at a disadvantage in terms of both prevention and treatment options. This phenomenon calls for urgent reforms in healthcare policies that target the root causes of these disparities. For example, Xu et al. highlighted that the uneven distribution of healthcare resources in China results in low-quality healthcare services in certain areas, and optimizing resource allocation is necessary to enhance public health. Chen et al. (1992) also found that insufficient healthcare service capacity in rural areas of western China leads to inequitable access to medical treatment, necessitating greater investment in improving service quality.

Health administrative personnel pointed out that regional health planning takes into account factors like population density and disease spectrum changes, but significant gaps in healthcare

resource distribution persist between the Pearl River Delta region and other areas. To bridge this gap, measures such as increased financial investment and resource guidance toward underdeveloped regions have been implemented. In response, investments in primary healthcare institutions and resource allocation optimization have been prioritized. While prioritizing investment in primary healthcare institutions, it is essential to not only increase the number of healthcare facilities but also to focus on improving the quality of existing institutions. Many of the primary healthcare centers, especially in remote regions, suffer from outdated infrastructure, insufficient equipment, and lack of specialized staff. Therefore, investments should also include upgrading medical equipment, expanding training programs for healthcare professionals, and implementing a continuous monitoring system to ensure that these resources are effectively utilized. Furthermore, improving the management and operational capacity of these institutions will contribute to long-term sustainability and help them meet the growing healthcare demands of their populations. Challenges in resource allocation, particularly in the context of the Guangdong-Hong Kong-Macao Greater Bay Area's collaborative healthcare development, include information sharing and policy coordination. These challenges are compounded by differing healthcare policies and regulatory environments across regions. Despite the collaborative efforts to enhance healthcare services in the Greater Bay Area, inconsistent policies across Guangdong, Hong Kong, and Macao have hindered effective resource sharing. For instance, while Guangdong focuses on expanding primary healthcare infrastructure, Hong Kong and Macao prioritize high-tech medical research and specialized services. This lack of policy harmonization often leads to inefficiencies and duplication of resources, further exacerbating regional disparities. Thus, a more unified approach to healthcare planning and policy coordination across the Greater Bay Area is critical to achieving a more integrated healthcare system that benefits all regions equally. Strengthening inter-regional cooperation and establishing information platforms have been proposed as solutions.

Healthcare institution administrators discussed equipment deployment, which considers urgency, cost-effectiveness, and patient flow. Brain drain, especially in departments like internal medicine and surgery, has been addressed through salary increases, improved working environments, and career development support. While government subsidies and medical service charges help with operation and maintenance, resource coordination within medical alliances remains difficult. Medical insurance settlement issues, such as poor information exchange and policy differences, can be mitigated by enhancing information systems and policy coordination. Health education and community cooperation have been effective in improving residents' health information literacy but require further government and community support.

Clinical medical personnel observed that resource shortages, such as insufficient equipment, medicine, and specialized staff, lead to diagnostic and treatment problems, especially for cross-referred patients. The application of new technologies like telemedicine faces challenges such as technical barriers and low patient trust, despite gradually increasing acceptance. While new technologies improve the doctor-patient relationship, they also introduce issues like technological dependence. In addition, the limited digital literacy of certain patient groups, especially the elderly, further complicates the adoption of telemedicine services. Even when technical platforms are available, a lack of confidence in operating digital devices or concerns about data privacy can hinder effective utilization, thereby limiting the potential benefits of technological advancement. Strengthening technical training, equipment updates, and policy support is recommended to enhance medical service quality. Healthcare professionals acknowledge problems in current health resource allocation policies and systems, including uneven distribution, insufficient funding, and inadequate implementation. In addition to these issues, the existing healthcare policies often fail to fully address the systemic inequalities that contribute to resource imbalances. For example, while there may be policies in place aimed at resource redistribution, their effectiveness is often undermined by poor implementation at the local level, where bureaucratic inefficiencies and a lack of accountability slow down progress. Furthermore, despite the allocation of financial resources to underdeveloped regions, these funds may not always be used effectively due to the lack of proper planning and oversight. A more transparent and accountable system, with clear guidelines for fund allocation and resource distribution, is necessary to ensure that the funds reach the intended healthcare institutions and are utilized to their maximum potential. They suggest increasing investment in primary healthcare, optimizing resource allocation mechanisms, and strengthening talent training.

Achieving a balanced allocation of healthcare resources is crucial for ensuring equal healthcare access and promoting population health. Given the variations in population size, distribution, and economic development, regional imbalances in healthcare resource allocation are particularly pronounced in Guangdong Province. Balanced allocation can eliminate regional disparities in healthcare resources, ensure equitable resource distribution, and enhance residents' health levels and quality of life. It can also improve the convenience and accessibility of healthcare services, making it easier for residents to obtain medical and health services. Balanced allocation, however, entails more than equal resource distribution; it involves rational utilization and strategic allocation. Achieving this balance requires not only a fair allocation of resources but also a strategic approach that aligns resource distribution with specific regional needs. For example, regions with a higher prevalence of chronic diseases may require a greater

focus on specialized healthcare services, while areas with a younger population may prioritize preventive care and maternal health services. Additionally, the design of healthcare infrastructure should reflect both population density and geographic distribution to ensure that healthcare facilities are accessible to all, even in the most remote areas. Therefore, balanced allocation should be based on a comprehensive understanding of regional healthcare needs and a tailored approach to resource deployment. To achieve this balance, factors such as population size, economic development level, and healthcare service demand must be considered. The realization of balanced healthcare resource allocation requires the collective efforts of the entire society and the strong support and participation of the government and all sectors of society. The government can increase investment in healthcare resource allocation to achieve balance. Health administrative departments at all levels can also take various measures, such as formulating sound policies on medical and health services and strengthening the supervision and management of these services, to ensure the realization of balanced resource allocation. While government policies and administrative measures play a pivotal role, it is essential that the private sector, non-governmental organizations, and the general public also contribute to the solution. Public awareness campaigns focused on the importance of equitable healthcare can help to generate societal pressure for more balanced resource allocation. In addition, partnerships between government bodies and private healthcare providers can also bring about innovative solutions, such as mobile health clinics or telemedicine services, to address the shortage of healthcare resources in underserved regions. This multi-sector collaboration is critical for achieving sustainable and equitable healthcare outcomes across Guangdong. In addition, all sectors of society can actively participate in the balanced allocation of healthcare resources by raising public awareness of healthcare services and supporting equitable resource distribution. Only through systematic and balanced resource allocation can all residents access equalized medical and health services, ultimately leading to overall health improvement. Furthermore, fostering a culture of accountability within the healthcare system is essential to ensure that resource allocation policies achieve their intended impact. Regular assessments, transparent reporting mechanisms, and active community participation in monitoring healthcare delivery can help maintain fairness and efficiency in the long term.

6.2.2 Multidimensional Analysis of Healthcare Resource Allocation across Guangdong Regions

This study adopts a microscopic perspective to examine the allocation of healthcare resources in 21 prefectural-level cities in Guangdong Province from 2011 to 2020, and collects data on

healthcare personnel, beds in healthcare institutions, beds in hospitals, mortality rates and related control variables, as well as data on the aging rate, urbanization rate, population density, and disposable income per capita. Through a combination of qualitative and quantitative research methods, this study analyzes a number of healthcare resource indicators such as mortality rate, number of healthcare technicians per 1,000 population, and number of beds per 1,000 population in different regions of Guangdong Province.

It is found that in terms of healthcare institutions, efforts to build and develop healthcare institutions are significantly higher in the PRD region than the eastern, western and mountainous regions of Guangdong from 2011 to 2020. The PRD region is economically developed, with a higher economic total volume and growth rate than other regions (*Notice of the People's Government of Guangdong Province on the Implementation of the Outline of the Plan for the Development of Guangdong, Hong Kong and Macao Greater Bay Area*, 14th document of the Guangdong provincial government in 2019). Specific data show that the average annual growth rate of the number of healthcare institutions in the PRD region is 8.5%, compared with 5.2%, 4.8% and 4.1% in eastern Guangdong, western Guangdong and the mountainous region respectively. This difference is mainly attributed to the stronger economic strength, higher population density and more favorable policy support of the PRD region. Nonetheless, the Guangdong provincial government has been gradually narrowing the inter-regional gap in recent years by increasing financial inputs to the less developed regions. For example, the number of healthcare institutions in eastern Guangdong increased by 35% in 2020 compared with 2011, indicating that the regional gap is gradually narrowing. However, although the number of healthcare institutions in less developed regions has increased considerably, their service capacity and quality of care still lag behind that of institutions in the PRD region. This discrepancy is not only reflected in the availability of advanced medical equipment and specialized departments, but also in the ability of these institutions to provide comprehensive services such as preventive care, chronic disease management, and high-level surgical treatment. The PRD region benefits from stronger infrastructure support and better integration of medical services, which enables its institutions to deliver more effective and timely care to patients. Many newly established institutions face challenges such as inadequate staffing, insufficient equipment, and limited capacity for specialized medical services. This means that while the quantitative gap in healthcare institutions has been reduced, the qualitative disparities remain significant. Therefore, the narrowing of the gap should be understood more in terms of infrastructure development, while substantial efforts are still required to enhance service delivery and healthcare outcomes in these areas. In addition, the PRD region is one of

the most densely populated areas in Guangdong Province, with a large and mobile population as well as greater demands for healthcare services. Despite the great effort in the construction of healthcare institutions in the PRD region, the investment in healthcare resources across Guangdong is relatively balanced, and the inter-regional gap is gradually narrowing. This trend is consistent with the findings of (Liu et al., 2020) that there is a decreasing trend in intra-regional, inter-regional and overall disparities. This change is mainly due to the policies implemented by the Guangdong provincial government, such as the “Plan for Strengthening Primary Healthcare and Creating Excellent Healthcare” between 2016 and 2018, which has invested 11.2 billion *yuan* to improve primary healthcare service capacity. Specific data shows that the number of primary healthcare institutions in eastern Guangdong increased by 40% between 2016 and 2020, and by 35% and 38% in western Guangdong and the mountainous region respectively. These measures have significantly enhanced the healthcare service capacity of less developed regions and promoted balanced development among regions. Moreover, the healthcare service system in Guangdong has continued to improve, and the mobility of healthcare talents has become increasingly more obvious, with doctors, nurses and other healthcare talents increasingly moving between regions. At the same time, technological innovation and informationization have also improved the quality and efficiency of healthcare services, and promoted information sharing and health service integration between regions, thus narrowing the gap between regions in terms of healthcare services. In addition, the integration of medical resources across regions has allowed patients from less developed areas to access high-quality medical services in the PRD region more conveniently, thereby partially compensating for local shortages. The increased use of referral systems and regional cooperation networks has also contributed to greater mobility of patients and healthcare professionals. Nonetheless, the dependence of residents in underdeveloped regions on medical institutions in the PRD indicates that the fundamental problem of insufficient local medical service capacity has not yet been completely solved. This reliance often results in patients traveling long distances to seek care, which increases both the financial burden and the time cost for families. In emergency situations, such delays can have particularly adverse consequences. Therefore, while inter-regional mobility of resources provides a temporary solution, the enhancement of local capacity remains the cornerstone for sustainable healthcare development. This suggests that while inter-regional mobility of healthcare resources has positive effects, sustainable improvements still rely on the enhancement of local medical institutions. In a national cross-section comparison, Guangdong province has been ranked first in China in terms of healthcare resource allocation (Sun & Yan, 2021).

In terms of healthcare staffing, this study also finds that the PRD region has better healthcare staffing resources than other regions. In addition to good economic development and policy support, high-quality educational resources in the PRD region also continuously train a large number of medical professionals for the region. The advantageous living environment and welfare benefits in the PRD region have also attracted more outstanding medical professionals to stay in the region. Despite the fact that health personnel resources in the PRD region are better than those in other regions, it is found that the gap between the PRD region and other regions in terms of healthcare workers and healthcare technicians is diminishing. This may be related to the fact that the government has introduced a series of policies to promote a balanced distribution of healthcare workers and healthcare technicians, including increasing support for the underdeveloped regions and encouraging healthcare workers to work in rural areas. Moreover, with the economic development in China, the revenues of health personnel in the PRD region and other regions have gradually become closer, which has made health personnel more willing to work in other regions. As a result, the gap in health personnel resources between regions has been narrowed. Despite this positive trend, it should be noted that the retention of medical personnel in less developed regions remains a persistent challenge. Many healthcare workers still prefer to work in the PRD due to better career development opportunities, higher academic exchange platforms, and more advanced medical facilities. Although financial subsidies and supportive policies have encouraged some medical personnel to relocate, long-term retention requires not only economic incentives but also improvements in professional development, career recognition, and working conditions. Hence, while the quantitative distribution of personnel has become more balanced, ensuring the stability and effectiveness of this distribution remains a key issue. A further difficulty lies in the uneven distribution of specialties, with highly trained professionals such as surgeons, anesthesiologists, and pediatricians still concentrated in large hospitals in the PRD region. Less developed areas often face shortages in these critical specialties, which directly affects their ability to provide comprehensive healthcare services.

In terms of the number of beds in healthcare institutions, the healthcare resource allocation in the PRD region is significantly better than that in other regions. Data of 2020 show that the number of beds per 1,000 population in the PRD region is 7.15, compared with 2.38, 4.22 and 2.98 in the eastern, western and mountainous regions of Guangdong respectively. The high population density (about 1,000 persons per square kilometer) and high level of economic activities in the PRD region provide a strong market demand for investment in healthcare resources. In addition, the average annual growth rate of the number of beds in the PRD region

is 5.8%, which is higher than that in eastern Guangdong (4.2%), western Guangdong (4.5%) and the mountainous region (3.9%). The Guangdong provincial government has gradually narrowed the gap between regions through financial support and social capital guidance. For example, the number of beds in western Guangdong increased by 36.8% between 2016 and 2020, indicating that the regional gap is gradually narrowing. Nevertheless, the capacity of beds alone cannot fully reflect the efficiency and quality of healthcare services. In less developed regions, even with the increase in bed numbers, the shortage of medical staff, advanced equipment, and specialized services reduces the overall utility of these resources. Conversely, in the PRD region, the combination of sufficient beds with advanced medical technology and skilled personnel ensures a higher level of service efficiency. This illustrates that while bed resources are essential, they must be matched with appropriate personnel and technological support to generate real improvements in healthcare delivery. However, the Guangdong provincial government has invested more in western Guangdong, eastern Guangdong and the mountainous region than in the PRD region, and the gap between the PRD region and the other regions in terms of bed resources in healthcare institutions is gradually decreasing. The Guangdong provincial government has formulated a series of policies to enhance the balanced allocation of health resources. For the western, eastern and mountainous regions of Guangdong, where there is a relative shortage of healthcare resources, the government provides financial support and encourages social capital investment to promote the construction of healthcare facilities. The gap between the PRD region and other regions is gradually narrowing, which is not only conducive to improving the health of the entire population in Guangdong, but also helps to promote the economic and social development of various regions of Guangdong. Due to data availability constraints, this study is unable to incorporate additional indicators reflecting the technical competence of medical personnel, such as the proportion of physicians with senior professional titles, the educational structure of licensed physicians, the level of standardized residency training, and the distribution of high-quality hospital resources. Therefore, the measurement of the quality of medical resources in this study remains incomplete. Future research could construct a more comprehensive evaluation system from both quantitative and qualitative dimensions to improve the accuracy and explanatory power of the findings.

In terms of healthcare expenditure, the absolute value of government healthcare expenditure in the PRD region is much higher than that in other regions, but the proportion of healthcare expenditure to fiscal expenditure is higher in other regions. The high healthcare expenditure in the PRD region is due to its high demand for healthcare services, concentration

of healthcare resources and greater financial strength. For example, the number of healthcare technicians per 1 000 population in the PRD region is 13.8, which is significantly higher than that in other regions. In contrast, medical resources are relatively scarce in the eastern, western, and mountainous regions of Guangdong, and the government needs to invest more capital to improve the quality and quantity of healthcare services. Nonetheless, the Guangdong provincial government has gradually narrowed the gap between regions through special transfer payments and policy guidance. In addition, with lower population densities and slower economic development, these regions may have a smaller demand for healthcare services. However, the government may still need to invest a high proportion of healthcare expenditure to meet the basic healthcare needs of the people. In addition, a high percentage of government healthcare expenditure does not necessarily mean that the quality of healthcare services in the region is good, nor does it necessarily mean that government healthcare expenditure is too high. To comprehensively assess the quality of healthcare services and the effectiveness of healthcare policies in a region, it is necessary to take into account a number of indicators, including the allocation of healthcare resources, the level of healthcare services, and the healthcare costs. For instance, a region with high fiscal expenditure on healthcare may still face inefficiencies if the funds are not effectively managed or if resource allocation does not correspond to the actual health needs of the population. Similarly, regions with lower healthcare expenditure may achieve relatively good outcomes if resources are allocated more rationally and efficiently. Therefore, assessing healthcare expenditure requires not only a comparison of financial inputs but also a comprehensive evaluation of efficiency, equity, and effectiveness in resource utilization. For instance, even with comparable levels of healthcare spending, differences in governance efficiency, institutional management, and the capacity to attract and retain qualified professionals can lead to significantly different health outcomes between regions. Thus, financial indicators should always be interpreted in conjunction with contextual institutional factors. This nuanced perspective allows for a better understanding of the actual impact of healthcare expenditure on population health.

6.3 Regional Disparities and Determinants of Population Health in Guangdong Province

The analysis of Guangdong Province's population health reveals substantial disparities among its regions, and these differences are closely linked to the uneven distribution of healthcare resources. Data drawn from population health surveys demonstrate that residents of the Pearl

River Delta (PRD) generally enjoy far better health outcomes than those living in other parts of the province. Specifically, people in the PRD exhibit lower prevalence of chronic diseases, higher levels of health literacy, and better control of blood pressure, blood glucose, and blood lipids. In contrast, residents of eastern, western, and northern Guangdong consistently perform worse across these indicators, revealing a marked imbalance in population health status. The PRD's urbanized and economically developed environment provides stronger healthcare infrastructure and more accessible medical services, whereas peripheral regions continue to struggle with insufficient investment, limited accessibility, and weak public health management.

These disparities arise from multiple, interrelated factors operating at both macro and micro levels. At the macroeconomic level, unequal regional development remains the most fundamental driver. The PRD's strong fiscal capacity enables continuous and large-scale investment in hospital construction, public health programs, and medical workforce development. By contrast, the economically less-developed regions of eastern, western, and northern Guangdong face fiscal constraints that limit their ability to improve healthcare facilities, update medical equipment, and retain qualified healthcare professionals. The result is a persistent gap in the availability and quality of healthcare services.

Moreover, educational attainment and health awareness play an important role in shaping health outcomes. Residents in the PRD, who generally have higher education levels, are more proactive in adopting preventive healthcare behaviors such as regular medical checkups, balanced diets, and physical exercise. They also have better access to health information and public education campaigns. In contrast, residents in less-developed regions often lack sufficient health knowledge, have limited exposure to preventive medicine, and are less likely to seek care until symptoms become severe. These behavioral differences are further compounded by variations in public health system capacity. Urban centers in the PRD maintain well-organized community health management systems, conduct routine chronic disease screening, and implement early intervention programs. Meanwhile, rural and mountainous regions lack comparable infrastructure and human resources, resulting in delayed detection and treatment of illnesses and a growing divergence in long-term health outcomes.

Quantitative regression analysis strongly supports the conclusion that the availability of healthcare resources is positively correlated with population health outcomes. Statistical results indicate that regions with a higher density of medical institutions, hospital beds, and healthcare professionals per capita tend to have lower rates of chronic illness, higher patient satisfaction, and greater utilization of preventive care services. These findings confirm that an adequate supply of healthcare resources not only improves treatment outcomes but also promotes

healthier behaviors and greater engagement in preventive health management. Conversely, insufficient healthcare investment in peripheral areas exacerbates health inequalities, leading to delayed treatment, higher out-of-pocket costs, and inadequate preventive care coverage. The resulting disparities reinforce a self-perpetuating cycle in which poor health limits economic productivity, and economic stagnation in turn restricts further investment in health infrastructure.

Qualitative data collected through semi-structured interviews provide additional depth to these findings and illustrate the practical consequences of resource inequality. Interviews were conducted with health administrators, hospital directors, and frontline clinical staff across multiple regions. Respondents from less-developed areas consistently reported shortages of medical equipment, insufficient operational funding, and high staff turnover as the major obstacles to healthcare delivery. Many hospitals, particularly at the county and township levels, are forced to transfer patients to higher-level institutions due to limited diagnostic capacity, outdated equipment, or insufficient specialist personnel. This pattern increases the economic burden on patients, disrupts continuity of care, and lowers the overall efficiency of the provincial health system.

A recurring theme in the interviews concerns the “talent drain” phenomenon, whereby skilled medical professionals migrate from under-resourced regions to urban hospitals in the PRD. The attraction of higher salaries, better career development opportunities, and superior research environments in large urban hospitals draws talent away from rural areas, creating a structural imbalance in healthcare human resources. The resulting shortage of qualified professionals in remote regions further undermines service quality and erodes patient trust in local healthcare institutions. Several respondents described this cycle as a “resource – health – talent trap,” where inequitable distribution of resources reduces health outcomes, poor outcomes discourage investment and staff retention, and the absence of skilled personnel perpetuates the original inequality. Unless addressed through coordinated policy reform, this systemic imbalance will continue to impede the realization of health equity across Guangdong Province.

The regional disparity in population health highlights the structural nature of health inequity, which is not merely the result of individual choices or lifestyle differences, but a consequence of systemic imbalances in healthcare governance and resource distribution. Improving population health in Guangdong therefore requires not only expanding the total volume of medical resources but also ensuring that these resources are allocated equitably and efficiently.

Policy interventions should prioritize the underdeveloped eastern, western, and northern parts of the province, where deficiencies in infrastructure, workforce, and health education are most pronounced.

From a policy perspective, several strategic actions are necessary to mitigate these inequalities. First, financial investment must be increased in less-developed regions, with fiscal transfer mechanisms designed to ensure stable and transparent funding for healthcare infrastructure and operational costs. Performance evaluation systems should incorporate both efficiency and equity indicators, balancing cost-effectiveness with accessibility and fairness. Second, long-term talent support mechanisms should be established to attract and retain healthcare professionals in rural and underserved areas. These may include differentiated promotion systems, targeted training programs, financial incentives, and career development pathways specifically tailored for those working in primary care or remote settings. Third, digitalization and information integration can play a transformative role in bridging regional gaps. Strengthening the interoperability of health information systems and cross-city medical insurance settlement mechanisms can enhance patient mobility, reduce administrative barriers, and allow real-time sharing of clinical data. This would not only improve service efficiency but also facilitate evidence-based resource allocation at the provincial level.

Equally important is the promotion of public health education and community participation. In many parts of eastern, western, and northern Guangdong, public health campaigns remain limited in scope and effectiveness. Residents' understanding of chronic disease prevention, nutrition, and mental health remains low, leading to unhealthy lifestyles and delayed care-seeking behaviors. To address this, local governments should invest in long-term, community-based health promotion programs, using both traditional media and digital platforms to disseminate accessible health information. Community health centers can collaborate with schools, workplaces, and non-governmental organizations to implement health awareness campaigns, free screening events, and educational workshops. Such initiatives would not only improve health literacy but also empower residents to take a more proactive role in managing their own health, thereby reducing the overall disease burden on the healthcare system.

The current situation in Guangdong thus reflects a distinct regional gradient in population health—the PRD stands at the forefront, while the eastern, western, and northern regions lag behind. This divide mirrors both economic inequality and systemic inefficiencies within the healthcare delivery system. The uneven distribution of medical resources has produced a structural health gap that cannot be resolved by increasing investment alone; rather, it calls for comprehensive governance reforms. Effective solutions require coordinated action among

multiple sectors—finance, education, human resources, and technology—to ensure that health equity is incorporated as a core dimension of regional development policy. Moreover, the design and implementation of health policies must emphasize feedback and accountability mechanisms, allowing for continuous monitoring, data-driven assessment, and adaptive adjustment of interventions based on measurable outcomes.

In essence, the disparities in Guangdong's population health stem from a complex interplay of economic, institutional, and sociocultural factors. Unequal access to healthcare resources remains the most direct determinant, while insufficient public health capacity and limited health education further amplify these inequalities. To achieve the strategic goal of “Healthy Guangdong,” policymakers must establish a fair and sustainable resource allocation system that prioritizes equity alongside efficiency. Fiscal transfers should be tied to measurable improvements in public health outcomes, and local governments should be encouraged to experiment with innovative models of regional cooperation, such as cross-regional hospital alliances, telemedicine networks, and shared health data platforms.

At the same time, strengthening primary healthcare institutions is essential for ensuring equitable access to basic medical services. These institutions serve as the first point of contact for most residents and play a critical role in disease prevention, health education, and chronic disease management. Investment in equipment, staff training, and service quality at the primary care level would significantly reduce the burden on tertiary hospitals and enhance the efficiency of the entire healthcare system. Coupled with targeted health education programs, these reforms would promote preventive health behaviors, reduce disparities in service utilization, and contribute to a more balanced population health profile.

In conclusion, As for the current health status of residents in Guangdong, it is found that the mortality rate of residents in the PRD region is lower than that in the other regions and also lower than the average level of Guangdong province, while the mortality rates of residents in eastern Guangdong, western Guangdong and the mountainous region are higher than the average level of Guangdong province. Taking into account the distribution of healthcare resources in various regions of Guangdong as analyzed earlier, the lower mortality rate in the PRD region may be attributed to the fact that it has a higher level of economic development, and its healthcare facilities are more comprehensive than those in other regions. Therefore, the people's standard of living and healthcare conditions are better, and the mortality rate is comparatively lower. On the other hand, due to the relatively low level of economic development in the eastern, western, and mountainous regions of Guangdong and the relatively

backward healthcare facilities, people's living standards and healthcare conditions are relatively poor and the mortality rate is therefore relatively high. Moreover, the higher mortality rates in these regions may also reflect the combined influence of social determinants of health, such as income level, education, and living environment, which are closely related to the accessibility and utilization of healthcare resources. The relatively backward infrastructure and limited healthcare awareness in these areas further aggravate the negative impact of resource shortages. Consequently, the mortality gap between the PRD region and other regions is not only the result of healthcare system disparities but also an indicator of broader socioeconomic differences across Guangdong Province. This reinforces the importance of a coordinated approach that simultaneously addresses healthcare resource allocation and regional socioeconomic development. Without addressing the structural socioeconomic disparities, improvements in healthcare resource allocation alone may have limited impact on reducing mortality differences. To overcome it, Guangdong must adopt a multi-level, integrated strategy—one that combines resource reallocation, capacity-building, and governance innovation. Through fiscal reform, health system strengthening, and sustained public health education, the province can gradually narrow the gap between regions and move toward a more equitable and healthier population. Achieving this transformation will require political commitment, interdepartmental collaboration, and the integration of health equity into all stages of policy design and implementation. Only through such comprehensive efforts can Guangdong progress from “partial health” toward “health for all,” establishing a more balanced, resilient, and inclusive public health system capable of supporting sustainable development in the years ahead.

6.4 Contribution to the theory on health resources allocation and its impact

This study utilizes the literature research method by reviewing the included 19 pieces of literature on healthcare resource equity analysis that meet the exclusion requirements. The research aims to comprehensively summarize and profoundly analyze the findings of Chinese scholars to establish a systematic theoretical foundation, thereby offering a more instructive reference for relevant studies.

6.4.1 Equity in health resource allocation

A total of 18 studies mention that health resources differ greatly between regions, including places such as Jiangsu Province, Guangxi Zhuang Autonomous Region, Anhui Province,

Guizhou Province, Heilongjiang Province, and Shanghai Municipality. It is essential to consider the historical context that underlies these discrepancies. The evolution of healthcare systems in China, where rapid economic development has often outpaced infrastructural adjustments in healthcare, plays a pivotal role in these inequalities. The transformation of healthcare in urban areas like Guangdong's Pearl River Delta region contrasts sharply with rural areas, where medical infrastructure and human resources remain limited. This imbalance has not only been a result of geographic and economic factors but also due to historical administrative decentralization, which has allowed local governments to control healthcare resources without sufficient oversight or incentives for equitable distribution. The persistence of this problem reflects deep-rooted structural barriers, such as the limited role of central government mandates and the insufficient integration of healthcare systems across regions. These structural barriers are not only institutional but also reflect the inertia of long-standing governance practices, where the fragmented decision-making process leads to inconsistencies in policy implementation across provinces. Moreover, the lack of unified evaluation benchmarks results in uneven progress, as some regions prioritize economic indicators over equitable healthcare development, thereby widening the disparity. However, the finding by Zhang represents a notable exception in the broader landscape of health resource distribution studies across China, suggesting that targeted policy interventions and sustained investment efforts in Liaoning Province may have contributed to achieving a more balanced distribution of medical resources. The relative equity observed in Liaoning's health resource allocation patterns indicates that systematic approaches to resource planning and distribution can yield measurable improvements in addressing traditional disparities between urban and rural healthcare provision.

There are large differences in the hardware and software of health resources in most regions. These disparities manifest across multiple dimensions of healthcare infrastructure, creating complex patterns of resource availability that vary not only between provinces but also within administrative boundaries of individual regions. The hardware-software imbalance observed across different provinces reflects systemic challenges in coordinating infrastructure development with human resource deployment, often resulting from misaligned planning processes and differential investment priorities between physical infrastructure expansion and professional workforce development. In many provinces, infrastructure projects have been rapidly advanced as a visible sign of development, yet without corresponding investments in training and retaining qualified personnel, the new facilities often remain underutilized or fail to deliver expected service outcomes. This mismatch reveals how policy emphasis on physical expansion alone cannot resolve fundamental equity issues. For instance, in Yunnan Province,

the inequity of health resources in terms of healthcare technicians is significantly higher than that in terms of hardware such as healthcare institutions and beds. In Shaanxi Province, the total number of nurses in the wards is not small, but compared to the actual deployment of beds, the overall staffing of healthcare technicians is still insufficient. The distribution of high-quality health resources in Anhui Province is poorly balanced. The inequitable allocation of health resources in some parts of Guangxi remains serious. The difference in equity between various types of health resources in Hengyang is obvious. In the number of healthcare technicians, registered nurses, practicing (assistant) physicians, and beds per 1,000 population, Heilongjiang Province and Shanxi Province still lag behind the national level during the same period. The number of healthcare technicians per 1,000 population in professional public healthcare institutions of Xinjiang is lower than the national level in that year, and the ratio of physicians to nurses in Ningxia is imbalanced and lower than the national level. In Liaoning Province, on the other hand, the number of hospitals/beds, health personnel, health technicians, physicians and nurses per 1,000 population is significantly higher than the national average level in that year.

6.4.2 Changing trends in health resources

Health resources in most places present a trend of gradual increase. The regions surveyed in the literature present a year-on-year increase in hardware and software such as healthcare institutions, healthcare technicians and healthcare institution beds during the survey period, and the health resources are mainly concentrated in the downtown area, but the total amount of health resources in the suburbs and remote areas has generally shown a year-on-year trend of increase. However, despite the overall growth in healthcare resources, this increase has been disproportionately distributed, further perpetuating existing regional inequalities. The uneven nature of this distribution is further compounded by urban-rural migration dynamics, where healthcare professionals are more likely to concentrate in metropolitan centers with better career opportunities, leaving peripheral regions chronically understaffed. Consequently, the numerical increase in resources fails to translate into meaningful improvements for vulnerable populations. For instance, in economically prosperous regions such as the Pearl River Delta, the rapid expansion of medical institutions and personnel fails to reach more remote areas, where healthcare professionals often face significant barriers to relocation due to economic and social factors. This trend underscores a paradox: while healthcare resources increase overall, rural and less economically developed regions often experience a relative decline in access, exacerbating health inequities. Therefore, it becomes apparent that merely increasing resources is insufficient

unless accompanied by strategic, targeted investments that consider both geographic and socioeconomic disparities. In addition, there were exceptions: the suburbs of Shanghai showed no increase in health resource allocation indicators during 2014 and 2015.. The allocation of health resources in some areas even shows a downward trend. For instance, the number of healthcare institutions per 1,000 population in Guangxi is declining from 2015 to 2017. The number of specialized public healthcare institutions per 1,000 population in Xinjiang is declining consecutively from 2015 to 2019, the number of practicing (assistant) physicians shows a fluctuated downward trend, and the number of healthcare technicians shows first an upward and then a downward trend. These declining patterns in specific regions underscore the complexity of healthcare resource dynamics, where local economic conditions, policy implementation effectiveness, and demographic changes can create divergent trajectories even within broader national improvement trends. The fluctuating nature of healthcare technician numbers particularly highlights the challenges associated with workforce retention and recruitment in certain geographic areas, suggesting that sustainable resource allocation requires sustained attention to underlying socioeconomic factors that influence healthcare professional mobility and career decisions.

6.4.3 Health resource allocation indexes

Most of the studies use Lorenz curve, Gini coefficient and Theil index for index analysis of health resource allocation, while a few studies use cluster analysis, entropy weight method, index of dissimilarity, DEA model and hot spot analysis.

6.4.4 Suggestions and countermeasures

Based on the literature study, the countermeasures and suggestions for health resource optimization are summarized from three dimensions: environment, demand and supply. Environment-based suggestions cover three dimensions of tax preference, service standard, and regulation and supervision. Demand-based suggestions include four dimensions of demonstration pilot, service outsourcing, cooperation mode, and market shaping. Supply-based suggestions involve six dimensions of technical support, infrastructure, information service, public service, capital investment, and talent cultivation. The high-frequency countermeasures focus on talent training, cooperation mode, capital investment and infrastructure.

The core suggestions in the talent training dimension include implementing a targeted training program for healthcare talents to strengthen the talent reserve for primary-level

positions, establishing a salary incentive mechanism for areas with insufficient talents to enhance the attractiveness of positions, building an employment guidance policy system and a benign talent mobility mechanism to promote balanced allocation of resources, and perfecting the full-cycle cultivation mechanism to synchronize the cultivation of talents with measures to curb the brain drain. The implementation of these talent-focused strategies requires careful consideration of regional economic disparities and career development opportunities, as sustainable talent retention depends not only on immediate financial incentives but also on creating comprehensive professional environments that support long-term career advancement and personal development within underserved areas. In this respect, continuous professional education, mentorship programs, and region-specific training bases are vital to ensure that healthcare workers in less developed areas can update their skills and remain competitive. Without such mechanisms, disparities in professional competency may widen, undermining the effectiveness of redistribution strategies. Suggestions for optimizing the cooperation mode focus on promoting the construction of medical alliances and the long-term mechanism of pairing assistance to channel quality resources toward the community level, building a platform for cross-regional health resource sharing to break down resource barriers, strengthening the collaboration of cities within the region, improving the integrated management system covering counties, townships and villages, and speeding up construction of the regional medical centers to enhance the radiation of services. The success of these collaborative frameworks depends heavily on establishing clear governance structures and accountability mechanisms that ensure equitable participation and resource sharing among partnering institutions, while maintaining quality standards and service accessibility across different administrative and geographic boundaries. Suggestions for optimizing capital investment include formulating preferential policies based on regional economic differences, establishing a financial input system based on demands, strengthening macroeconomic regulation and control, increasing transfer payments to less developed regions to alleviate distributional imbalances, constructing a performance evaluation mechanism for resource utilization, and dynamically optimizing the efficiency of inputs and outputs to eliminate the waste of resources. Suggestions for improvement of infrastructure include strengthening the standardized construction of public health infrastructure in remote and less developed areas, dynamically adjusting the allocation of beds in conjunction with the population size and the demand for medical care to avoid a mismatch of resources, and optimizing the spatial distribution of healthcare institutions to ensure a reasonable match between healthcare human resources and bed resources. The coordination of infrastructure improvements with workforce development initiatives represents a critical

component of sustainable healthcare system strengthening, requiring integrated planning approaches that consider both immediate service delivery needs and long-term demographic and epidemiological transitions that will shape future healthcare demand patterns across different regions and population groups.

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Chapter 7: Conclusion

7.1 Research conclusion

In the building a harmonious society, it is crucial to pay attention to the health equity of residents in different regions of Guangdong. The pursuit of health equity represents not merely a public health objective but a fundamental component of social justice and sustainable development within China's broader modernization framework. Guangdong Province, as a pivotal economic engine and demographic center, serves as a critical case study for understanding how regional development patterns influence population health outcomes and healthcare accessibility across diverse geographic and socioeconomic contexts. The health status of residents in different regions of Guangdong is also a comprehensive indicator of the level of economic development and medical security in China. This multifaceted relationship between health outcomes and broader development indicators reflects the complex interdependencies between economic growth patterns, healthcare infrastructure investment, and population welfare distribution that characterize contemporary Chinese provincial development trajectories. This thesis focuses on the empirical study of the impact of uneven allocation of health resources on the health disparities of residents in different regions of Guangdong. From the perspective of health equity of residents in different regions of Guangdong, this study explores in-depth the main reasons affecting the health of residents in different regions of Guangdong. The PRD region has formed a “siphon effect” by virtue of its financial advantages, this concentration mechanism operates through multiple channels, including preferential resource allocation policies, enhanced infrastructure development opportunities, and superior professional advancement prospects that collectively attract both human and financial capital away from peripheral regions. The resulting resource concentration creates self-reinforcing cycles of advantage that systematically disadvantage less economically developed areas. This uneven development trajectory not only consolidates the dominance of already prosperous regions but also progressively erodes the resilience of peripheral areas, where the lack of sustained investment diminishes the capacity to attract skilled professionals and maintain modern service delivery standards. Over time, this cumulative imbalance becomes deeply entrenched, making it increasingly difficult for underdeveloped regions to narrow the gap. While less developed regions are constrained by

structural contradictions such as delayed construction of primary healthcare institutions and poor promotion pathways for professional title of healthcare workers. These structural limitations create cascading effects throughout the healthcare delivery system, where inadequate infrastructure investment constrains service capacity, while limited professional development opportunities reduce the attractiveness of positions in these regions, thereby exacerbating workforce shortages and service quality disparities that ultimately compromise population health outcomes.

In addition, barriers to inter-regional healthcare insurance settlements and differences in health information literacy further exacerbate health inequalities. These systemic barriers create additional layers of complexity in healthcare access, where administrative obstacles compound geographic and economic constraints to limit healthcare utilization, particularly for populations requiring specialized services or cross-regional care coordination. For many rural residents, the administrative complexity of navigating reimbursement procedures discourages timely medical visits, while the absence of interoperable health information platforms further prolongs referral processes. As a result, individuals facing acute or chronic conditions often experience fragmented care pathways, reducing the effectiveness of available medical interventions. The variation in health information literacy across different regions reflects broader educational and digital divide issues that influence individuals' capacity to navigate healthcare systems effectively and make informed health decisions. With data from 21 cities over the past 10 years as the sample, we conduct an in-depth study of the core issues, and the empirical results are basically consistent with the initial assumptions, which indicates that we have achieved the design objectives. The alignment between theoretical expectations and empirical findings validates both the conceptual framework underlying this research and the methodological approaches employed to examine the complex relationships between healthcare resource distribution and population health outcomes. Such alignment also demonstrates the robustness of the analytical design, indicating that the selected indicators effectively capture both the quantitative dimensions of healthcare resources and the qualitative implications for population health. This coherence reinforces the explanatory power of the research and enhances its applicability for policymaking. This consistency strengthens confidence in the policy implications derived from the analysis. The results show that changes in the number of hospital beds per 1,000 population and the number of healthcare workers per 1,000 population in different regions of Guangdong have a significant negative correlation with the differences in mortality rates among residents in different regions of Guangdong. These quantitative relationships demonstrate the tangible impact of healthcare resource availability on

fundamental health outcomes, suggesting that investments in both physical infrastructure and human resources yield measurable improvements in population health indicators. The strength of these correlations underscores the critical importance of addressing resource disparities as a means of achieving more equitable health outcomes across different geographic areas. By highlighting the measurable relationship between healthcare resources and mortality differences, the findings provide compelling evidence that equity-driven interventions can yield tangible improvements in population health. This empirical grounding lends urgency to policy efforts aimed at recalibrating the distribution of both physical and human healthcare resources. The phenomenon that medical resources in the PRD are superior to those in other regions exerts a negative impact on the health equity of residents in different regions of Guangdong, and residents in the mountainous region have a relatively low level of health compared to those in the PRD region. In order to realize health equity for residents in different regions of Guangdong, policies must be adopted to improve the uneven allocation of health resources in different regions of Guangdong, so as to reduce inter-regional disparities and promote social harmony.

7.2 Suggestions

Drawing on the identified patterns of resource concentration in the PRD and the persistent constraints faced by mountainous and other less developed regions, the recommendations below emphasize strengthening primary-level capacity, refining funding arrangements, and improving residents' access to essential services. Each recommendation corresponds to documented disparities in infrastructure, personnel distribution, and service availability.

7.2.1 Increase the proportion of fixed assets invested in primary healthcare institutions

The government should increase its investment in healthcare resources, especially in the upgrading of equipment and training of personnel in primary healthcare institutions. Given cost considerations and the need to safeguard operational efficiency, a pragmatic approach is to strengthen policy guidance and targeted financial support so as to promote rational allocation and effective utilization of existing resources. The macroeconomic policies will guide primary healthcare institutions to increase investment in fixed assets. In the PRD region, community healthcare institutions covering urban residents have been established, and commonly used medical equipment such as routine biochemical testing equipment have been purchased for community healthcare institutions. In the mountainous region, primary healthcare institutions are investing in the expansion of housing construction and the purchase of routine biochemical

equipment to accelerate the construction of standardized clinics. In recent years, the provincial government has gradually increased investment in county-level hospitals. In the future, investment in fixed assets in county-level hospitals should continue to increase, specifically investment in housing, construction and specialized medical equipment. Priority should be given to equipment that directly enhances diagnostic and treatment capacity at the primary level, together with structured in-service training that improves day-to-day service quality and supports stable workforce retention in underserved localities. In addition, investment strategies should be carefully tailored to local conditions, recognizing that the infrastructure requirements of urban community health centers differ markedly from those of township clinics in remote mountainous areas. Aligning fixed asset allocation with specific service demands ensures that scarce resources produce the maximum possible improvement in service delivery and patient outcomes.

7.2.2 Increase financial investment in primary healthcare institutions

In light of the relatively weak fiscal capacity and market position of primary healthcare institutions in mountainous areas, direct government investment should be strengthened to stabilize basic service provision and compensate for revenue reductions following pricing reforms. However, primary healthcare institutions in the mountainous region cannot receive sufficient financial support from the government, which in turn has led to insufficient healthcare resources and a relatively disadvantaged position in the overall market environment. Therefore, the government should increase its direct investment in the allocation of basic healthcare resources to compensate for the reduction in income faced by medical institutions after the abolition of the drug markup. This will increase the proportion of government health investment in the revenues of primary healthcare institutions, and encourage them to more effectively demonstrate their public welfare attributes. To be specific, the government should focus on strengthening the proportion of personnel, financial resources and materials invested in hospitals and health stations in the mountainous region, so as to optimize the allocation of basic healthcare resources. Moreover, fiscal support should incorporate transparent performance evaluation mechanisms, ensuring that additional subsidies are directly linked to measurable improvements in service coverage, patient satisfaction, and equity outcomes. This accountability-driven approach strengthens the efficiency of government expenditure and mitigates the risk of resource misallocation. Such support should be linked to clearly defined service responsibilities at the primary level, ensuring that additional inputs translate into improved coverage of essential services and more balanced distribution of personnel and basic

equipment.

7.2.3 Improve the accessibility of health resources for residents in different regions of Guangdong

With the rapid expansion of health insurance coverage and the rollout of recent healthcare protection policies, the difficulty of obtaining medical services has been alleviated to some extent across regions of Guangdong. After the introduction of a new healthcare reform program in 2009, the government has made efforts to increase residents' access to healthcare resources, especially for residents in the mountainous region. However, there is still a gap between the PRD region and the other regions in Guangdong. In order to spare all poor and disadvantaged groups from aggravating diseases, we must consider the accessibility of healthcare resources in the development of healthcare reform. In particular, we should provide residents in mountainous regions with accessible healthcare resources, so that residents of different regions can have equally convenient access to healthcare services, and it is also an approach to realize health equity for residents in Guangdong. Special attention should also be directed toward transportation and communication infrastructure in mountainous areas, as the physical accessibility of facilities remains a critical determinant of service utilization. By reducing the time and cost required to reach medical institutions, residents in disadvantaged regions can benefit more fully from the expanded coverage of insurance and healthcare reform initiatives. Priority should be accorded to improving service availability in township- and village-level facilities in mountainous areas, consolidating referral pathways between primary and higher-level institutions, and facilitating inter-regional settlement processes so that residents can access appropriate care without undue administrative or financial burdens.

7.2.4 Enhance basic services and cross-regional coordination

For regions outside the Pearl River Delta, interventions should first focus on consolidating basic service capacity at the primary level, including enhancing routine diagnostic and management capabilities for common chronic conditions and improving outreach services for dispersed communities. These efforts should be accompanied by organizational collaboration mechanisms that facilitate the orderly flow of patients and the sharing of high-quality services across administrative boundaries. Within the Pearl River Delta metropolitan cluster, optimization should emphasize coordination across jurisdictions and the standardization of procedures that enable residents to obtain continuous care. Removing administrative barriers to

cross-regional settlement and refining cooperation among institutions will help extend the benefits of concentrated resources to a broader population, thereby narrowing disparities. To maximize the effectiveness of such coordination, clear governance frameworks should be established to delineate responsibilities among different administrative levels, thereby preventing duplication of efforts and ensuring continuity of care. Regular inter-jurisdictional reviews can further consolidate cooperative practices and adapt them to evolving healthcare demands.

7.2.5 Regular review and timely adjustment of health resources

A dynamic allocation mechanism should be established to regularly monitor equity and efficiency indicators and to adjust inputs in a timely manner when imbalances emerge. Funding arrangements ought to be responsive to observable service capacity and utilization, encouraging institutions to improve performance while directing additional support to areas with clear shortfalls in essential services. In parallel, reserve arrangements for emergency medical resources should be put in place in regions with higher proportions of older residents, so that equipment and personnel can be rapidly mobilized to meet surges in service demand. Equally important is the establishment of feedback loops between monitoring results and policy adjustments, enabling decision-makers to respond promptly to emerging imbalances. Such a dynamic system would help maintain both equity and efficiency over the long term, ensuring that healthcare resources remain aligned with demographic changes and epidemiological transitions.

7.3 Summary and outlook

At the present stage, the core task of regional health planning is to optimize the allocation of healthcare resources and guide the flow of resources in the direction of low cost and high health benefits. To be specific, resource allocation should be adjusted in accordance with population density and disease burden, so as to address the problem of excess of resources in economically developed regions and shortage of resources in less developed regions, channel the quality resources down to the community level, promote health equity, and enhance the residents' health. In practical terms, this means that provincial and municipal health authorities must not only consider macro-level economic indicators but also closely examine the actual healthcare demands of different populations, including demographic aging trends, patterns of disease prevalence, and projected population mobility. A more precise matching between healthcare

resources and regional health needs would help to prevent both the underutilization of resources in developed areas and the persistent scarcity in underdeveloped ones. Moreover, strengthening the downward extension of high-quality medical resources to grassroots healthcare institutions can play a crucial role in improving the accessibility and affordability of healthcare services, thereby gradually narrowing the health gaps between urban and rural residents. Only through sustained adjustment and continuous monitoring can such optimization efforts avoid the pitfalls of one-time interventions that lose relevance over time. Long-term effectiveness hinges on embedding equity considerations into every stage of planning, implementation, and evaluation.

Against the backdrop of rapid economic growth, China faces the daunting challenge of equity and efficiency in healthcare resource allocation and healthcare service utilization. In 2015, for example, according to the assessment of healthcare resource allocation efficiency in 31 provinces, 10 (32.26%) of the provinces had high allocation efficiency, 7 (22.58%) had low efficiency, and 14 (45.16%) had very low efficiency. It indicates that there are significant differences in resource allocation efficiency between provinces in China (Sun & Luo, 2017). These differences imply that some regions are able to convert healthcare inputs into tangible health outcomes more effectively, while others suffer from inefficiencies arising from inadequate management capacity, limited technical expertise, and insufficient healthcare infrastructure. For provinces with low efficiency, even substantial financial investment may fail to yield commensurate health benefits if resource allocation mechanisms remain poorly optimized. Consequently, addressing the institutional and administrative barriers that hinder efficient resource utilization becomes as essential as increasing the overall volume of healthcare funding. Primary healthcare resource density is highest in the eastern part of China, and lowest in the western part. This spatial disparity indicates that residents in western provinces often encounter considerable obstacles in accessing basic medical services, ranging from long travel times to insufficient availability of essential medications and diagnostic technologies. The uneven distribution of healthcare personnel, particularly qualified doctors and nurses, further aggravates these problems, as patients in resource-scarce regions frequently experience delayed diagnoses, limited treatment options, and lower overall service quality. As a result, healthcare outcomes in such regions remain persistently below the national average, creating a pressing need for targeted interventions to rebalance healthcare supply. According to Y. Zhang et al. (2018), primary health care institutions are inefficient in more than 80% of the provinces, mainly due to insufficient funding and brain drain of professional talents, which further exacerbates inter-regional health inequality. A few provinces have achieved a balance between equity and efficiency in the allocation of healthcare resources. For example, Hainan, Shandong,

and Zhejiang have significantly improved service efficiency and equity by increasing financial investment in primary healthcare institutions and optimizing resource allocation, which serves as reference for other regions (L. Zhang et al., 2024). Although existing studies have revealed the imbalance of healthcare resource allocation among regions in China, studies targeting Guangdong Province are still insufficient, especially lacking a comprehensive analysis of resource allocation efficiency and health equity. This study will fill this gap and provide a scientific basis for optimizing health resource allocation in Guangdong Province. In addition, health resource allocation efficiency is generally used to reflect the utilization of health services and health resource density is generally used to reflect the equity of health resource allocation in existing studies. The indicators to evaluate healthcare resource allocation are unable to describe the current status of regional allocation of healthcare resources in a multidimensional way. This study constructs a multidimensional indicator system to objectively assess the current status of healthcare resource allocation in Guangdong Province. (1) The Gini coefficient is used to measure the regional differences in the proportion of healthcare investment. (2) The differences in the allocation of financial, human, and material resources among regions are analyzed through the Theil index. (3) The data envelopment analysis (DEA) is adopted to assess the allocation efficiency of healthcare institutions. (4) The gap in the geographic accessibility of resources is measured by the geographic information system (GIS) technology.

In the rural areas of China, uneven distribution of healthcare resources is significantly associated with the relatively high morality of children under the age of five. With the increase of healthcare resources, the morality of children under the age of five tend to decrease (Tam et al., 2016). A study within Guangdong Province shows that the highest two-week prevalence rates are concentrated in the central (namely, PRD) and northern regions of Guangdong Province, where the two-week prevalence rates are higher than 25% compared to 10%-20% in other regions. According to the corresponding Lorenz curves and Gini coefficients, there is a moderate level of imbalance in the distribution of healthcare resources in these regions, revealing that there is a certain degree of correlation between the even distribution of healthcare resources and health of the residents (Wen et al., 2021). In general, there are few relevant studies on the impact of uneven regional allocation of healthcare resources on residents' health in Guangdong Province. In order to comprehensively promote the construction of Healthy Guangdong and implement the important instruction of prioritizing the protection of people's health in the strategic position of development, it is urgent to find out whether the regional allocation of healthcare resources in Guangdong Province exerts an impact on the residents' health. Such an inquiry requires not only an assessment of statistical correlations between

resource allocation and health outcomes but also a careful exploration of the underlying mechanisms linking resource distribution to residents' healthcare behaviors, service utilization rates, and ultimate health status. By clarifying these pathways, policymakers can better design interventions that directly address the most critical bottlenecks in resource allocation and thereby improve both efficiency and equity in the healthcare system. If there is indeed such an impact, we should explore the mechanism of the impact and countermeasures, so as to promote the sustainable development of the healthcare industry and lay a solid health foundation for the rejuvenation of the Chinese nation.

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Annex A: List of Supplemental Tables

Table a.1 Literature retrieval

Database	Number of academic articles
Wanfang	1008
CNKI	1174
Chongqing VIP	476
In total	2658

Table a.2 Results of literature retrieval

Title	Time	Journal
Study on equity in health resource allocation in Hengyang from 2010 to 2014	2017	Chinese Health Economics
Analysis of the efficiency of healthcare resource allocation in Jiangsu Province from 2011 to 2020	2023	Chinese Health Economics
Equity analysis of health resource allocation in Shanghai from 2012 to 2015	2017	Chinese Health Resources
Study on the current situation and equity of health resource allocation in Guangxi from 2015 to 2017	2020	Chinese Journal of Health Policy
Equity analysis of health resource allocation in Anhui Province from 2010 to 2012	2014	Medicine and Society
Study on the equity of healthcare resource allocation in Chongqing from 2016 to 2020	2022	Chinese Journal of Health Policy
Equity analysis of health human resource allocation in Guizhou Province	2019	Medicine and Society
Equity analysis of health human resource allocation in Heilongjiang Province	2019	Chinese Health Economics
Study on the classification of regional health resources in Hubei Province	2019	Chinese Health Resources
Equity analysis of health resource allocation in Ningxia based on Gini coefficient and difference index	2016	Chinese Health Economics
Equity analysis of health resources in Liaoning based on Gini coefficient and Lorenz curve	2012	Medicine & Philosophy
Status and efficiency of allocation of Chinese medicine and health resources in Beijing-Tianjin-Hebei region	2021	Chinese Health Resources
Study on the equity of health human resource allocation in Inner Mongolia Autonomous Region	2020	Chinese Health Economics
Study on equity and prediction of health resource allocation in Shandong Province	2022	Modern Preventive Medicine
Equity analysis of health resource allocation in Shanxi Province	2021	Chinese Journal of Health Policy
Equity analysis of health resource allocation in county-level public general hospitals in Shaanxi province	2020	Chinese Journal of Health Statistics
A study on the spatio-temporal characteristics of equity and efficiency of health resource allocation in Wuhan	2021	Medicine and Society
Analysis of spatial equity in the level of supply of health resources in specialized public health institutions in Xinjiang	2022	Chinese Health Service Management
Equity analysis of health resources in Yunnan Province	2017	Chinese Health Resources

Table a.3 Indicators for evaluating the efficiency of healthcare expenditure

Input indicators	Fiscal expenditure indicators	Government healthcare expenditure Per capita disposable income
		The number of healthcare institutions per 1,000 population
		The number of health workers per 1,000 population
Output indicators	Health resource indicators	The number of health technicians per 1,000 population
		The number of practicing (assistant) physicians per 1,000 population
		The number of beds in healthcare institutions per 1,000 population

Table a.4 Indicators of healthcare resource allocation efficiency and their directions

Indicator	Indicator attribute	Variable
The number of healthcare institutions per 1,000 population	Positive	X1
The number of beds in healthcare institutions per 1,000 population	Positive	X2
The number of health technicians per 1,000 population	Positive	X3
The number of practicing (assistant) physicians per 1,000 population	Positive	X4
The number of health workers per 1,000 population	Positive	X5

Table a.5 Coding table for literature content analysis based on equity and trends

SN	Literature	Starting point	End point	Literature analysis unit
1	Equity analysis of health resources in Yunnan Province_Dai Jing	2: 1190	2: 1240	Although the total amount of medical and health resources in Yunnan Province has been on the growth, the problems of uneven resource distribution and irrational resource allocation are still prominent.
2	Equity analysis of health resources in Yunnan Province_Dai Jing	2: 1047	2: 1072	The amount of health resources has been increasing year by year, both in terms of software and hardware.
3	Equity analysis of health resources in Yunnan Province_Dai Jing	2: 1047	2: 1072	The amount of health resources has been increasing year by year, both in terms of software and hardware.
4	Spatial equity analysis of health resource supply level of specialized public health institutions in Xinjiang_Chai Liping	2: 1488	2: 1520	The number of practicing public health institutions has been decreasing year after year, with an average annual growth rate of -6.25%.
5	Spatial equity analysis of health resource supply level of specialized public health institutions in Xinjiang_Chai Liping	2: 1523	2: 1554	The number of practicing (assistant) physicians showed a fluctuating downward trend, and the number of health technicians first rose and then fell.
...				
46	Current situation of health resource allocation and research on equity in Guangxi from 2015 to 2017_Peng Rong	4: 93	4: 185	From 2015 to 2017, the number of beds, health technicians, physicians and nurses per 1,000 population in Guangxi showed an upward trend, with growth rates of 12.23%, 11.20%, 10.51% and 16.41%, respectively.
47	Current situation of	4: 187	4: 223	In contrast, the number of healthcare

SN	Literature	Starting point	End point	Literature analysis unit
	health resource allocation and research on equity in Guangxi from 2015 to 2017_Peng Rong			institutions per 1,000 population showed a downward trend, with a growth rate of -3.06%.

Note: The coding table for literature content analysis based on the policy instruments is shown as per Table a.6.
Table a.6 Coding table for literature content analysis based on policy instruments

SN	Literature	Starting point	End point	Literature analysis unit
1	Equity of healthcare resource allocation in Chongqing from 2016 to 2020_Wu Mingyang	8: 167	8: 239	Deepen the promotion of medical associations, counterpart support, and multi-site practice for physicians, encourage multi-site practice of physicians or regular outpatient visits and rounds, promote the rational flow of health resources, and promote the realization of the common building and sharing of health resources.
2	Equity of healthcare resource allocation in Chongqing from 2016 to 2020_Wu Mingyang	8: 268	8: 285	Increase government investment and offer support through appropriate policies
3	Equity of healthcare resource allocation in Chongqing from 2016 to 2020_Wu Mingyang	8: 287	8: 356	Build and improve basic medical and healthcare services and strengthen support for remote and underdeveloped areas; at the same time, focus on upgrading the economic development of various regions in Chongqing and balance the allocation of medical and healthcare resources in each region.
4	Equity of healthcare resource allocation in Chongqing from 2016 to 2020_Wu Mingyang	8: 458	8: 577	Promote the vertical flow of high-quality resources and the horizontal balance of inter-regional and intra-regional resources. With the opportunity of the rapid development of Internet medical care, Chongqing should actively expand the radiation scope of high-quality medical resources, transform the medical service model, accurately make up for the shortcomings of intra-regional resource allocation, and comprehensively integrate and optimize the allocation of medical and healthcare resources in Chongqing.
5	Equity analysis of health resources in Yunnan Province_Dai Jing	4: 1145	4: 1153	Establishment of a mechanism for the flow of talents
64	Equity of health resource allocation in Hengyang from 2010 to 2014_Wu Yafei	5: 1164	5: 1327	The government should establish employment-oriented policies to guide the flow of health technicians to primary healthcare institutions; it should improve the mechanism for training health personnel, formulate incentive

SN	Literature	Starting point	End point	Literature analysis unit
65	Equity of health resource allocation in Hengyang from 2010 to 2014_ Wu Yafei	5: 1164	5: 1327	policies to encourage graduates to work at the grass-roots level, and improve the compensation and benefits of health technicians; and it should establish a reasonable mechanism for the flow of talents to allay the concerns of health technicians that they will have fewer opportunities for their own personal development, promotion of professional title, and further learning after they go to the primary healthcare institutions, so as to gradually improve the disparities in the equity of human resources for health between regions. The government should establish employment-oriented policies to guide the flow of health technicians to primary healthcare institutions; it should improve the mechanism for training health personnel, formulate incentive policies to encourage graduates to work at the grass-roots level, and improve the compensation and benefits of health technicians; and it should establish a reasonable mechanism for the flow of talents to allay the concerns of health technicians that they will have fewer opportunities for their own personal development, promotion of professional title, and further learning after they go to the primary healthcare institutions, so as to gradually improve the disparities in the equity of human resources for health between regions.

Note: The coding table for literature content analysis based on the evaluation methods is shown as per Table a.7.
Table a.7 Coding table for literature content analysis based on evaluation methods

SN	Literature	Starting point	End point	Literature analysis unit
1	Equity of healthcare resource allocation in Chongqing from 2016 to 2020_ Wu Mingyang	2: 375	2: 383	The number of health technicians
2	Equity of healthcare resource allocation in Chongqing from 2016 to 2020_ Wu Mingyang	2: 385	2: 393	The number of practicing (assistant) physicians
3	Equity of healthcare resource allocation in Chongqing from 2016 to 2020_ Wu Mingyang	2: 420	2: 424	The number of available beds
4	Equity of healthcare resource allocation in Chongqing from 2016 to 2020_ Wu Mingyang	2: 395	2: 399	The number of registered nurses
5	Equity of healthcare resource allocation in Chongqing from 2016 to 2020_ Wu Mingyang	2: 414	2: 418	The number of healthcare institutions
...				

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SN	Literature	Starting point	End point	Literature analysis unit
123	Equity of health resource allocation in Hengyang from 2010 to 2014 _Wu Yafei	1: 2553	1: 2556	Registered nurses
124	Equity of health resource allocation in Hengyang from 2010 to 2014 _Wu Yafei	1: 2580	1: 2583	The Theil index

Note: The final coding results are shown as per Table 4.3.

Table a.8 Government healthcare expenditure in different regions of Guangdong Province from 2011 to 2020a (Unit: 0.1 billion yuan)

Year	Guangdong	PRD	Eastern Guangdong	Western Guangdong	Mountainous region	PRD/Eastern Guangdong	PRD/Western Guangdong	PRD/Mountainous region
2011*	433.7500	30.0494	12.0688	13.6107	9.0700	2.4898	2.2078	3.3131
2012*	505.1400	36.4765	14.5485	15.8119	10.2500	2.5072	2.3069	3.5587
2013*	569.3200	40.0805	16.2889	18.0798	10.7300	2.4606	2.2169	3.7354
2014*	777.5500	56.9480	22.5296	25.0495	14.6800	2.5277	2.2734	3.8793
2015	918.3600	57.0719	28.6284	28.7042	38.4789	1.9935	1.9883	1.4832
2016	1121.8300	72.9549	34.7933	31.3836	43.7099	2.0968	2.3246	1.6691
2017	1307.5600	88.9531	37.6289	35.5042	46.2818	2.3640	2.5054	1.9220
2018	1407.5100	95.3503	41.3804	36.2972	48.0152	2.3042	2.6269	1.9858
2019	1579.6000	107.5819	42.2396	40.3916	53.7110	2.5469	2.6635	2.0030
2020	1772.9900	128.8887	43.8491	42.6651	55.8432	2.9394	3.0209	2.3080

a. Government healthcare expenditure in each region is the average value of the region including all the prefecture-level cities.

*. There is a lack of data for Dongguan and Jiangmen in the PRD region, Shanwei in western Guangdong, and Zhanjiang and Maoming in the mountainous region.

Table a.9 Percentage (%) of government healthcare expenditure in different regions of Guangdong Province from 2011 to 2020

Year	Guangdong	PRD	Eastern Guangdong	Western Guangdong	Mountainous region	PRD/Eastern Guangdong	PRD/Western Guangdong	PRD/Mountainous region
2011	6.4619	5.1524	13.1995	13.1995	5.9871	1.9736	2.5618	1.1620
2012	6.8374	5.9024	12.9549	12.9549	5.4777	1.7463	2.1949	0.9281
2013	6.7688	5.5507	13.2322	13.2322	4.6207	1.7810	2.3839	0.8324
2014	8.4954	6.8117	15.8780	15.8780	6.1634	1.6529	2.3310	0.9048
2015	7.1591	6.0993	10.3588	12.5008	12.4120	1.6983	2.0495	2.0350
2020	8.3432	7.0715	12.2755	13.7010	14.1001	1.7359	1.9375	1.9939
2017	8.6953	7.7501	12.7626	14.4662	13.6489	1.6468	1.8666	1.7611
2018	8.9483	8.0890	12.3698	13.4727	12.7170	1.5292	1.6656	1.5721
2019	9.1318	8.3199	11.5414	13.3272	13.3879	1.3872	1.6018	1.6091
2020	10.1716	10.0537	11.6546	13.2767	13.2103	1.1592	1.3206	1.3140

Table a.10 Disposable income per capita in different regions of Guangdong Province from 2011 to 2020 (Unit: *yuan*)

Year	Guangdong	PRD	Eastern Guangdong	Western Guangdong	Mountainous region	PRD/Eastern Guangdong	PRD/Western Guangdong	PRD/Mountainous region
2011	19083.6829	27916.55563	16441.96	17230.8	14745.416	1.6979	1.6202	1.8932
2012	21572.7918	31222.075	18747.99	19673.65	16647.452	1.6654	1.5870	1.8755
2013	23420.7500	32069.85111	18007.5225	21902.7	17947.856	1.7809	1.4642	1.7868

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2014	25685.0000	33642.14065	14948.73817	15782.01156	15448.50359	2.2505	2.1317	2.1777
2015	27858.8600	36661.9747	16344.84319	17274.72999	16895.88348	2.2430	2.1223	2.1699
2020	30295.8000	40109.12209	17967.56308	18744.64769	18364.51087	2.2323	2.1398	2.1841
2017	33003.2900	43840.12118	19657.14073	20206.66681	20016.42697	2.2302	2.1739	2.1902
2018	35809.9000	47911.02129	21287.99268	21754.18015	21690.95423	2.2506	2.2024	2.2088
2019	39014.2800	52213.65798	23120.26439	23483.56078	23550.91949	2.2584	2.2234	2.2171
2020	41028.6300	54809.63283	24504.71676	24575.56555	25087.37126	2.2367	2.2302	2.1847

Note: Data sources: Guangdong Statistical Yearbook (2011–2020) and Statistical Yearbooks of Prefectural-level Cities in Guangdong Province.

Table a.11 Pure technical efficiency of different regions in Guangdong Province from 2011 to 2020

Region	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Mean
Guangdong	1.00	1.00	1.00	0.87	0.88	0.89	0.89	0.90	0.90	0.90	0.92
PRD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Eastern Guangdong	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Western Guangdong	1.00	0.96	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99
Mountainous region	1.00	1.00	1.00	1.00	0.99	1.00	0.99	0.99	0.99	0.98	0.99

Table a.12 Scale efficiency of different regions in Guangdong Province from 2011 to 2020

Region	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Mean
Guangdong	0.93	0.94	0.88	0.95	0.94	0.99	0.99	0.99	0.99	0.99	0.96
PRD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Eastern Guangdong	1.00	1.00	1.00	1.00	0.94	1.00	1.00	1.00	1.00	1.00	0.99
Western Guangdong	0.98	0.96	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99
Mountainous region	1.00	1.00	1.00	1.00	0.78	0.95	0.95	0.96	0.93	0.91	0.95

Table a.13 Information entropy of healthcare resource allocation in Guangdong from 2011 to 2020

Indicator	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Entropy	0.606	0.607	0.607	0.608	0.608	0.627	0.626	0.625	0.626	0.626
Information entropy	0.103	0.102	0.103	0.102	0.102	0.097	0.098	0.098	0.098	0.098

Table a.14 Information entropy healthcare resource allocation among different regions in Guangdong

Year	Indicator	Per 1,000 population in Guangdong	Per 1,000 population in PRD	Per 1,000 population in eastern Guangdong	Per 1,000 population in western Guangdong	Per 1,000 population in the mountainous region
2020	Entropy	0.852	0.835	0.851	0.881	0.863
	Information entropy	0.206	0.229	0.208	0.166	0.190
2015	Entropy	0.834	0.827	0.818	0.853	0.832
	Information entropy	0.199	0.207	0.218	0.176	0.201
2011	Entropy	0.831	0.823	0.820	0.854	0.831
	Information entropy	0.201	0.211	0.214	0.174	0.201

Table a.15 The weights of healthcare resource allocation among different regions in Guangdong based on the entropy weight method

Indicator	Indicator weight in 2011	Indicator weight in 2015	Indicator weight in 2020
Number of healthcare institutions per 1,000 population	0.1829	0.2126	0.3797
Number of beds in healthcare institutions per 1,000 population	2.5896	3.4532	3.9293
Healthcare technicians per 1,000 population	4.6246	5.6216	4.6736
Practicing (assistant) physicians per 1,000 population	1.9209	2.2527	2.6389
Healthcare workers per 1,000 population	6.1269	7.3358	8.7124

Table a.16 The weights of healthcare resource allocation in Guangdong from 2011 to 2020 based on the entropy weight method

Healthcare resource allocation indicators	Indicator weights
Number of healthcare institutions per 1,000 population	0.380
Number of beds in healthcare institutions per 1,000 population	3.929
Healthcare technicians per 1,000 population	4.674
Practicing (assistant) physicians per 1,000 population	2.639
Healthcare workers per 1,000 population	8.712

Table a.17 Frequency of regional allocation and total resource

Equity	Classification	Frequency	Relative frequency (%)	Total frequency
Regional allocation	Huge regional disparity	18	100	100
	Relatively good equity	0	0	
Total resource	Huge disparity between hardware and software	9	11.11	100
	Relatively good equity	1	88.89	

Table a.18 Frequency of hardware and software

Classification	Trend	Frequency	Relative frequency (%)	Total frequency
Software	Growth	2	18.18	100
	Decline	9	81.82	
Hardware	Growth	8	12.50	100
	Decline	1	87.50	

Table a.19 Frequency of policy types

Policy type	Policy name	Frequency	Relative frequency (%)	Total frequency (%)
Supply-based policy	Talent training	15	23.08	66.15
	Capital investment	12	18.46	
	Public service	2	3.08	
	Infrastructure	7	10.77	
	Technical support	4	6.15	
	Information service	3	4.62	
Environmentally-oriented policies	Regulatory supervision	2	3.08	7.69
	Financial service	0	0.00	
	Medical insurance support	0	0.00	
	Service standard	2	3.08	
	Tax incentives	1	1.54	
	Demonstration pilot	1	1.54	
Demand-based policy	Government purchase	0	0.00	26.15
	Service outsourcing	1	1.54	
	Market shaping	2	3.08	
	Cooperation mode	13	20.00	

Table a.20 Comparison of health status and lifestyle between residents with different degrees of education

Variable	Group with higher degree of education	Group with lower degree of education	Statistic	<i>p</i>
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Physical activity (Times/week)	3.2±1.5	1.8±1.2	t =4.23	<0.001
Regular physical examination rate (%)	72.2	59.3	$\chi^2 =18.45$	<0.001
Smoking rate (%)	13.6	35.5	$\chi^2 =12.34$	<0.001
Drinking rate (%)	22.4	35.2	$\chi^2 =8.76$	<0.05

Table a.21 Comparison of health status and lifestyle between residents with different geographic locations

Variable	Downtown area group	Suburb group	Rural-urban fringe group	Statistic	<i>p</i>
Physical activity (Times/week)	3.5±1.2	2.8±1.0	2.0±1.5	F=12.45	<i>P</i> <0.001
Regular physical examination rate (%)	78.5	65.2	52.3	$\chi^2 =18.34$	<i>P</i> <0.001
Smoking rate (%)	12.0	20.5	30.2	$\chi^2 =15.67$	<i>P</i> <0.001
Drinking rate (%)	25.0	30.0	35.0	$\chi^2 =6.78$	<i>P</i> <0.05

Annex B: List of Questionnaires

The first part: personal investigation

A. Basic Information:		
A1	Sex	1 Male 2 Female
A2	Your ethnicity	1 Han Ethnicity 2 Zhuang Ethnicity 3 Manchu Ethnicity 4 Hui Ethnicity 5 Tibetan Ethnicity 6 Other Ethnicities
A3	Your area of residence	1 Eastern Guangdong 2 Western Guangdong 3 Northern Guangdong 4 Pearl River Delta region
A4	The geographic location of the area where you live	1 City Center 2 Suburb/Suburban Area 3 Urban-Rural Fringe/Urban-Rural Interface
A5	Your level of education	1 No Formal School Education 2 Incomplete Primary School 3 Primary School Graduate 4 Junior High School Graduate 5 High School/Technical Secondary School 6 Junior college 7 Undergraduate 8 Postgraduate and above
A6	Your current marital status	1 Unmarried 4 Widowed 2 Married 5 Divorce 3 Living together 6 Separation
A7	Your occupation	1 Production personnel of agriculture, forestry, animal husbandry, fishery and water resources 2 Production, transportation equipment operators and related personnel 3 Business, service personnel 4 Heads of state organs, party and mass organizations, enterprises and institutions 5 Clerical and related personnel 6 Professional technical personnel 7 Servicemen 8 Other Workers

		9 Students in school 10 Unemployed 11 Housework 12 Retired personnel
A8	Are you covered by social health insurance?	1 Yes 2 No
A9	Do you have any comments or suggestions about your current health situation? (Please explain briefly)	

The second part: Lifestyle and chronic disease survey

A. Lifestyle		
A1	On average, how many times per week do you engage in moderate or higher intensity physical activity?	1 0 times 2 1-2 times 3 3-4 times 4 More than 5 times
A2	Do you smoke now, every day, not every day, or not?	1 Yes, every day 2 Yes, but not every day 3 Used to smoke, but not now 4 Never smoke
A3	Do you drink now, every day, not every day, or not at all?	1 Yes, every day 2 Yes, but not every day 3 Used to drink, but not now 4 Never drink
Bood pressure, blood sugar, blood lipid		
B. Blood pressure and its control		
B1	Did you know your blood pressure before taking this survey?	1 Higher than the normal range 2 Normal 3 Below the normal range 4 Have no idea
B2	Do you take steps to control your blood pressure?	1 Yes 2 No
B3	What is your view on your own blood pressure situation? (Please briefly explain.)	
C. Blood sugar and control		
C1	Were you aware of your blood sugar before taking this survey?	1 Higher than the normal range 2 Normal 3 Below the normal range 4 No sure
C2	Are you taking steps to control your blood lipids?	1 Yes 2 No
C3	What is your view on your own blood sugar situation? (Please briefly explain.)	
D. Blood lipid and its control		
D1	Were you aware of your blood sugar before taking this survey?	1 Higher than the normal range 2 Normal 3 Below the normal range 4 No sure

J2	In the last six months, when you felt that your illness was relatively mild, which of the following institutions did you choose to visit?	1 Provincial Hospital 2 Municipal Hospitals 3 district level hospitals 4 geriatric hospital 5 Community Health Service Centers 6 Enterprise or military hospital 7 Private clinics 8 Self-medication 9 Others
J3	In the last six months, when you felt that your illness was relatively serious, which of the following institutions did you choose to see a doctor?	1 Provincial Hospital 2 Municipal Hospitals 3 district level hospitals 4 geriatric hospital 5 Community Health Service Centers 6 Enterprise or military hospital 7 Private clinics 8 Self-medication 9 Others
J4	How long do you feel about waiting in line at a community health service centre?	1 Very long 2 Relatively long 3 Normal 4 Shorter 5 Very Short
J5	When you see a doctor in the community health service center (station), how do you feel about the service attitude of the medical staff?	1 Very good 2 Good 3 Neutral 4 Poor 5 Very poor
K.Health literacy self-evaluation		
K1	How do you consider your level of health literacy?	1 Very healthy 2 Healthy 3 Unhealthy 4 Very unhealthy

The third part: Health service survey

A. Medical resources cognition		
A1	How satisfied are you with the services at the hospital or clinic where you live?	1 Very dissatisfied 2 Dissatisfied 3 Neutral 4 Satisfied 5 Very satisfied
A2	Do you think there are enough doctors and nurses in the hospital or clinic where you live to take care of all the people who need it?	1 Very sufficient 2 Sufficient 3 Adequate 4 Somewhat insufficient 5 Insufficient
A3	Do you think the medical machines and equipment in the hospital where you live, such as X-ray machines and CT machines, can meet the needs of	1 Very satisfied 2 Satisfied 3 Adequate 4 Somewhat dissatisfied

	people to see a doctor?	5 Dissatisfied
A4	What are your specific suggestions for improving medical service satisfaction? (Please briefly explain.)	
B. Medical resource needs assessment		
B1	Do you think the government in your area gives enough financial support to hospitals and clinics?	1 Yes 2 No
C. Rational allocation of medical resources		
C1	Do you think the allocation of medical resources where you live is reasonable?	1 Very reasonable 2 Reasonable 3 Somewhat unreasonable 4 Unreasonable
D. Distribution of medical facilities		
D1	What is the distribution of hospitals or clinics where you live?	1 Mostly located in the city center 2 Mostly located in the suburbs 3 Mostly located in the urban-rural fringe
E. Satisfaction with medical services		
E1	How satisfied are you with the hospitals and clinics where you live?	1 Very dissatisfied 2 Dissatisfied 3 Neutral 4 Satisfied 5 Very satisfied
E2	Do hospitals and doctors in your area provide fair care to those in need, such as low-income families and people living in remote areas?	1 Yes 2 No 3 Not sure
E3	What do you think can be improved in the allocation of medical resources to better serve different populations? (Please briefly explain.)	

1. Purpose of the Interview

To gain an in-depth understanding of the specific manifestations, influencing factors, and mechanisms of action of unequal health resource allocation in practical operations, and to provide robust qualitative data support for subsequent research analysis and policy recommendations.

2. Interview Participants

This study included interview participants from three distinct groups to ensure the comprehensiveness and representativeness of the findings:

(1) Health Administrative Personnel: A total of 16 interviewees were selected from the Planning Division of the Guangdong Provincial Health Commission and the Health and Wellness Bureaus of various cities. Purposive sampling was employed to select managers familiar with regional healthcare policies and resource allocation, ensuring their ability to provide a macro-level perspective on resource distribution and policy implementation.

(2) Healthcare Institution Managers: A total of 48 interviewees were included, comprising 8 hospital directors from tertiary hospitals, 16 vice-presidents in charge of operations from secondary hospitals, and 24 heads of primary healthcare institutions. Stratified sampling was used, with healthcare institutions stratified by level (tertiary, secondary, and primary), and a random selection of managers from each stratum was made to reflect the resource allocation and management status at different levels.

(3) Clinical Healthcare Workers: A total of 96 interviewees were selected, including physicians from obstetrics and gynecology, pediatrics, and radiology, as well as public health personnel. Convenience sampling was employed to select representative healthcare workers who were accessible and able to share insights into resource allocation and healthcare accessibility from a practical operational perspective.

3. Interview Content

a. For Health Administrative Personnel:

(1) Regional Health Planning

① What specific factors (e.g., population density, changes in disease spectrum, efficiency of existing resource utilization) are primarily considered when determining the allocation of health resources during the development of regional health planning?

② How do you view the current disparities in health resource allocation between the Pearl River Delta region and other areas? How is this gap reflected and considered in the planning process? Are there any specific adjustment measures?

③ Could you share the greatest difficulties and challenges encountered during the implementation of health planning? What solutions were adopted to address these challenges?

④ When dynamically adjusting health resource allocation, how do you balance the structural contradiction between the demand for elderly care services and the short-term healthcare needs of migrant workers? What priority-setting or resource allocation strategies have been implemented?

(2) Performance Evaluation of Resource Allocation

① What are the main criteria currently used for evaluating the performance of health resource allocation (e.g., resource utilization efficiency, service accessibility, improvements in population health)? How were these criteria determined?

② How is the impact of resource allocation on health disparities specifically quantified within the evaluation system? Have association models been established between health outcome indicators (e.g., mortality rates, prevalence of chronic diseases) and resource allocation (e.g., number of beds per thousand people, number of health workers)? Please provide examples.

③ Based on previous evaluation results, which aspects of resource allocation have been most prominent (e.g., geographical disparities, imbalances between human and material resources)? What specific improvement measures have been implemented to address these issues?

(3) Regional Collaborative Development

① Within the framework of healthcare collaboration in the Guangdong-Hong Kong-Macao Greater Bay Area, what challenges does the current resource allocation mechanism face in adapting to cross-border healthcare service demands? What specific measures have been taken to address these challenges?

② If an additional 10% health budget allocation were provided, which aspect of resource allocation would you prioritize improving? Why?

③ Compared to the Yangtze River Delta region, what unique advantages and shortcomings do you believe exist in Guangdong's health resource allocation mechanisms?

b. For Healthcare Institution Managers:

(1) Equipment Configuration and Talent Retention

① How does the hospital determine priorities in equipment configuration? For example, when purchasing large equipment such as CT/MRI, what factors are primarily considered (e.g., urgency of equipment needs, cost-effectiveness, patient volume)?

② What has been the extent of talent loss in the hospital in recent years? In which departments

or positions has this loss been most concentrated (e.g., internal medicine, surgery)? What do you believe are the main reasons for talent loss (e.g., salary, working environment, career development opportunities)?

③ What specific measures has the hospital taken to address talent loss and insufficient equipment configuration? How effective have these measures been? Could you share some successful cases?

(2) Primary Healthcare Institution Development

① What are the main challenges in the standardized construction of primary healthcare institutions (e.g., funding shortages, insufficient technical support)? After hardware facilities meet standards, how is the operation and maintenance funding addressed?

② How do you view the collaborative relationship between primary healthcare institutions and higher-level hospitals? What are the main difficulties and challenges in medical consortium construction (e.g., information sharing, resource coordination)? How do you think these collaborative mechanisms can be improved?

③ What specific suggestions do you have for improving the service capacity of primary healthcare institutions (e.g., improving service quality, enhancing patient satisfaction, upgrading medical technology levels)?

(3) Health Insurance Settlement and Health Information Literacy

① What practical problems has the hospital encountered in cross-city health insurance settlement (e.g., information barriers, policy differences)? How can coordination issues between the insured place and the medical service location be resolved?

② How do you view patients' confusion and dissatisfaction during the health insurance settlement process? What specific measures has the hospital taken (e.g., strengthening training, optimizing processes) to improve patient satisfaction?

③ What specific work has the hospital done to improve residents' health information literacy? How effective has this work been? What additional support and cooperation do you think are needed (e.g., government policies, community collaboration)?

c. For Clinical Healthcare Workers:

(1) Impact of Resource Shortages on Diagnosis and Treatment

① When receiving patients referred across regions, what typical diagnostic and treatment problems caused by resource allocation differences have you observed (e.g., insufficient equipment, drug shortages, lack of specialists)? Please describe the handling process of these issues in detail.

(2) Physician-Patient Relationship and Technology Application

① What specific difficulties and challenges have you encountered in the application of new technologies such as telemedicine (e.g., technical barriers, patient trust, operational complexity)? How receptive are patients to remote diagnosis?

② What specific roles do you think new technologies play in improving the physician-patient relationship? Are there any negative impacts? Please provide examples.

③ In improving medical service quality, what specific support and improvements do you think are needed (e.g., technical training, equipment upgrades, policy support)?

(3) Views on Policies and Systems

① From your perspective, what specific shortcomings exist in the current health resource allocation policies and systems (e.g., uneven resource distribution, insufficient funding, inadequate policy implementation)? What impact have these shortcomings had on your work?

② What specific suggestions do you have for improving the uneven distribution of health resources (e.g., increasing investment at the primary level, optimizing resource allocation mechanisms, strengthening talent development)? What specific measures do you think the government and relevant departments should take?

③ How do you evaluate the actual effectiveness of the "County Project" county medical center construction in alleviating uneven resource distribution (e.g., resource coverage, service accessibility, improvements in population health)?

4. Interview Methods

Face-to-face semi-structured in-depth interviews were conducted, with each interview lasting 60–90 minutes. A pretest was performed before the interview to optimize question design. During the interview, detailed records were kept, and probing questions were used to clarify ambiguous information, ensuring the reliability and accuracy of the data.

5. Interview Approach

The interview adopted a multi-level semi-structured design, covering policymakers, institutional managers, and clinical healthcare workers:

① Administrative Decision-Making Level: One-on-one interviews were conducted with 16 leaders in charge of the Health and Wellness Bureaus in eight sample cities across four regions in Guangdong Province: the Pearl River Delta (Guangzhou, Dongguan), Eastern Guangdong (Shantou, Meizhou), Western Guangdong (Zhanjiang, Yangjiang), and Northern Guangdong (Shaoguan, Qingyuan). These interviews focused on the basis for regional health

planning, fiscal transfer payment mechanisms, and performance evaluation criteria for resource allocation, resulting in a verbatim transcript of 2.4 million words. These interviews aimed to gain an in-depth understanding of policymakers' views on the issue of uneven resource allocation and its impact on health disparities among residents.

② Institutional Management Level: In 48 sample medical institutions, 8 tertiary hospital directors, 16 vice-presidents in charge of secondary hospitals, and 24 heads of primary healthcare institutions were selected for focus group discussions (six people per group). These discussions systematically analyzed equipment configuration priorities and the main causes of talent loss, yielding 53 key cases of conflict. These discussions helped reveal the coping strategies of institutional managers in the context of uneven resource allocation and its impact on health disparities among residents.

③ Clinical Implementation Level: Special interviews were conducted with 96 physicians and public health workers in resource-shortage-prone departments, including obstetrics and gynecology, pediatrics, and radiology. The critical incident method was used to record 28 referral cases due to insufficient equipment and 12 types of outpatient services canceled due to staff shortages over the past three years. These interviews helped understand the work challenges faced by frontline clinical staff in the context of uneven resource allocation and its impact on patient health.