Research on the Optimization Path of Discipline Construction in Public Hospitals Based on Socio-technical System Theory

-Nvivo Coding and Gephi Network Analysis

Xueke Hui[1], Rongrong Pang[2,*], Yuan Wang[3], Shengcong Tao[4], Hao Chen[5], Wei Zhang[2]

[1]Lanzhou Maternal and Child Health Hospital, Lanzhou, China
[2]Gansu University of Traditional Chinese Medicine, Lanzhou, China
[3]The First People's Hospital of Lanzhou city, Lanzhou, China
[4]Lanzhou Health Statistics Information Center, Lanzhou, China
[5]Lanzhou Municipal Medical and Health Insurance Supervision and Service Guidance Center, Lanzhou, China

1144625580@qq.com(Xueke Hui),
*15025914011@163.com(Rongrong Pang)

Abstract. Objective: The high-quality development of public hospitals is a national strategy, with disciplinary construction as the core path and driving force, yet facing challenges like policy fragmentation and insufficient cross-sectoral synergy. Methods: Drawing on the four dimensions of socio-technical systems theory (social, technical, organizational, institutional), this study used Nvivo for three-level coding of 200 policy texts and Gephi to construct a node network, analyzing core issues and cross-dimensional linkages. Key findings reveal bottlenecks including fragmented top-level design in the organizational dimension, lack of dynamic assessment in the institutional dimension, and weak techno-social integration. Suggestions: A four-dimensional optimization framework is proposed: "innovating disciplinary synergy to break interdepartmental barriers", "strengthening data sharing with dynamic monitoring systems", "optimizing policy issuance mechanisms for resource allocation efficiency", and"enhancing top-level design to formulate coherent disciplinary development plans".

Keywords: discipline construction; socio-technical systems theory; four-dimensional linkage optimization path; policy research

1 Introduction

The high-quality development of public hospitals is crucial for safeguarding public health[1] and advancing the Healthy China strategy[2]As medical demands evolve from basic services to high-quality, efficient, and precise care—exacerbated by aging popu-

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lations and changing disease spectrums[3]—China issued key policies in 2021, including the Opinions on Promoting High-Quality Development of Public Hospitals and corresponding 2021–2025 action plans, prioritizing talent development, scientific research, and discipline construction[4]. Discipline construction—strategic development of clinical specializations and research capabilities—serves as a core engine for healthcare quality, driving clinical excellence through specialized expertise, enabling advanced diagnostic/therapeutic technologies for precision care, enhancing complex disease management capacities, and fostering skilled medical talent. While scholars have explored dimensions like health insurance reform[5], evaluation systems, and performance metrics[6], this study applies socio-technical systems (STS) theory to analyze 200 policy texts via NVivo, model policy networks with Gephi, and examine discipline construction across social, technical, organizational, and institutional dimensions to propose targeted recommendations.

2 Applicability of Socio-Technical Systems Theory

Socio-technical Systems Theory (STS), pioneered by Trist et al. through British coal mine labor studies, asserts that organizational effectiveness stems from dynamic interactions between social systems (people, norms, relationships) and technical systems (tools, processes, infrastructure), rejecting technological determinism in favor of joint optimization where technical tools align with human capabilities and social structures adapt to technological possibilities [7].

In healthcare, STS offers a critical framework for addressing systemic fragmentation: hospitals operate as complex ecosystems where clinician expertise (social), diagnostic technologies (technical), departmental workflows (organizational), and accreditation standards (institutional) continuously interact, with failures in any dimension—such as misaligned incentives or siloed data systems—undermining care quality and innovation. For public hospital discipline construction, STS highlights the need to coherently link talent development, digital integration, governance design, and policy frameworks to overcome challenges(Fig. 1).

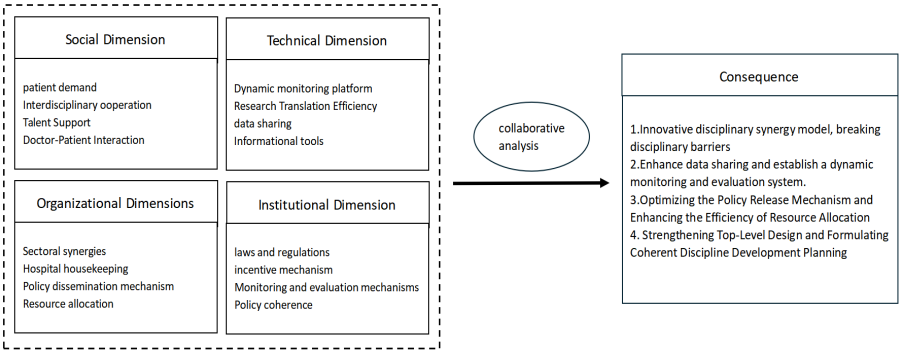

Fig. 1. Framework for analyzing socio-technical systems theory

3 Research Methodology and Sources

3.1 Policy Text Collection

This study analyzed policy documents on public hospital discipline construction issued by China's State Council, National Health Commission (NHC), and other ministries (2012–2025). Samples (n = 200) were collected from official government portals (e.g., Central People's Government, NHC) and databases (e.g., Peking University Law Database) using keywords: "public hospitals," "high-quality development," and "discipline construction." See Table 1 for details.

Table 1. Summary of documents included in the analysis

Serial number	Name of the document	Release time	issuing authority
1	The General Office of the State Council on promoting the construction and development of medical consortiums guidance Guo Ban Fa [2017] No. 32	2017	Central People's Government of the People's Republic of China
2	Opinions of the General Office of the State Council on Promoting the Development of "Internet + Healthcare" (Guo Ban Fa [2018] No. 26)	2018	Central People's Government of the People's Republic of China
3	Evaluation Indicators for High-Quality Development of Public Hospitals (for Trial Implementation) (State Health Office Medical Letter [2022] No. 335)	2022	National Health Commission, State Administration of Traditional Chinese Medicine
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199	Circular of the Office of the People's Government of the Dali Bai Autonomous Prefecture on the Issuance of the Implementation Plan for the Pilot Construction of the "Daxiangwei" Close-knit Urban Medical Group (Dazhengban Fa [2024] No. 72)	2024	People's Government of Dali Bai Autonomous Prefecture
200	Implementation Opinions of the General Office of the Shanghai Municipal People's Government on Strengthening the City's Clinical Research System and Capacity Building in Support of the Development of the Biomedical Industry (Shanghai Municipal Office Regulation [2024] No. 11)	2024	Shanghai Municipal People's Government

3.2 Research Methodology

3.2.1 Three-level Coding Analysis.

NVivo 20, a qualitative analysis software developed by QSR International[8], was employed for grounded theory-based text analysis. Policy documents were systematically coded through word frequency analysis and three-level coding to categorize key issues.

3.2.2 Social Network Analysis.

Social Network Analysis (SNA) examines network structures through relational patterns [9]. Using Gephi software (v0.9.2), we quantified node relationships derived from NVivo coding to visualize policy networks.

3.2.3 Gephi.

Gephi, an open-source network visualization tool developed by international researchers, facilitates SNA through graphical representations of social data connections[10].

4 Research Process and Analysis

4.1 Word Frequency Analysis

Using NVivo 20 with Chinese settings (minimum word length=2), we analyzed 200 policy documents on public hospital discipline construction, filtering irrelevant terms with a stop-word list. Word frequency analysis identified the 50 most frequent terms, and a word cloud visualization (Fig. 2) highlighted core concepts like "hospital," "medical," and "health" via font centrality/size (Table 2). While quantifying key themes, qualitative coding is crucial for deeper contextual analysis.

Fig. 2. Word cloud of discipline building in public hospitals

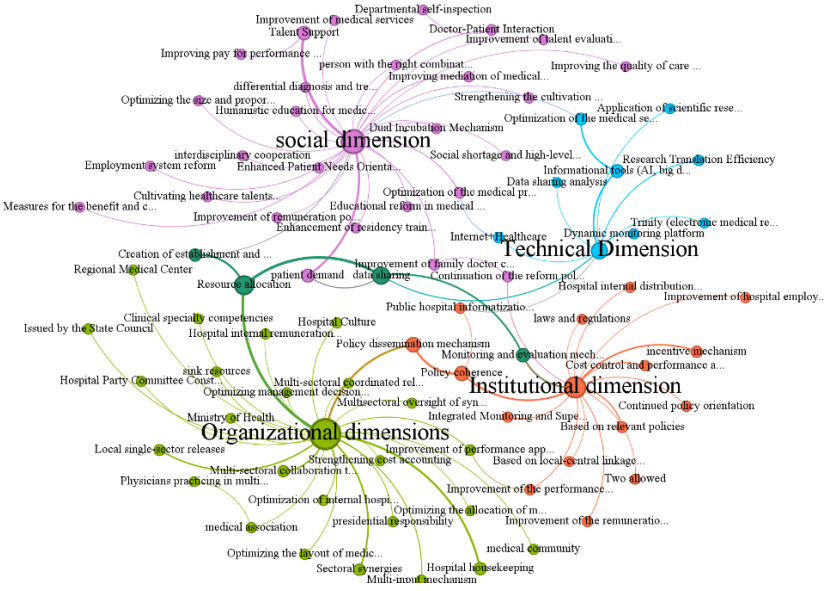

Fig. 3. Social network diagram dimensions

Table 2. List of high frequency words from the literature in the sample

list of words	reckoning	Weighted percentage (%)	list of words	reckoning	Weighted percentage (%)
hospital	12466	1.94	Work	9971	1.10
medical	11253	1.75	System	6705	1.05
health	9077	1.41	Health	5972	0.93
management	10923	1.28	Public	5811	0.91
service	7455	1.14	Construction	5756	0.90

4.2 Three-stage Coding Process

This study implemented a structured three-stage coding process using NVivo20 software to analyze 200 policy documents.

4.2.1 Open Coding Stage.

The initial open coding involved line-by-line text analysis to identify key concepts from raw data points[11].Through systematic examination, we generated over two thousand reference points that were organized into discrete tertiary nodes.This established foundational categories for further analysis.

4.2.2 Axial Coding Stage.

Building on open coding results, axial coding restructured conceptual relationships by grouping related concepts while preserving contextual integrity, consolidating hundreds of granular nodes into sixteen well-defined secondary nodes representing major thematic dimensions.

4.2.3 Selective Coding Stage.

The final selective coding phase integrated all coded material theoretically.Systematic comparison revealed four core analytical dimensions with significant explanatory power.Complete results showing this conceptual progression are presented in Table 3.

Table 3. Coding of disciplines in public hospitals

serial number	primary node	secondary node	Tertiary nodes (example)	reference points
1	Technical Dimension	Dynamic monitoring platform	Intelligent monitoring system, central and local sharing of healthcare-related dynamic construction, intelligent detection platform for healthcare insurance, multi-point triggered monitoring, early warning and emergency command, multi-disciplinary dynamic monitoring platform Public Hospital Reform Detection Platform	40
2		Research Translation Efficiency	Translation of clinical research results, clinical trials of artificial intelligence products, drug clinical research, market transformation of results, new drug and device development	60

3		data sharing	Five centers for sharing medical resources, telemedicine collaboration network, sharing of electronic medical records and electronic health records, sharing of test results and examination data, and big data center for health care, etc.	70
4		Informational tools	Internet+Healthcare, Internet+Pre-Hospital Medical Services, Online Contracting Platform Construction, "Trinity", Smart Wearable Devices, Unified Clinical Research Information Platform, Cross-Regional Telesurgery, Intelligent Healthcare Supervision and Services	142
5		patient demand	Graded diagnosis and treatment, measures for the benefit of the public and the convenience of the public, all-process medical care, two-way referral, family doctor contracting, optimization of the mode of medical care, diagnostic and treatment outpatient clinics, multidisciplinary diagnostic and treatment model	241
6	social dimension	interdisciplinary cooperation	Cross-fertilization of basic research and clinic, multidisciplinary integration of research platforms, synergy between clinical research and clinical treatment, interdisciplinary clinical collaboration between Chinese and Western medicine, clinical and biomedicine	29
7		Talent Support	"Jianghuai famous doctors" training project, complex talents, public health team "strong foundation and solid foundation" plan, the training of talents in shortage of specialties, flexible attraction of talents, special program for rural doctors, physician multi-practice.	346
8		Doctor-Patient Interaction	Improvement of mediation in medical disputes and humanistic education for medical personnel	40
9		Sectoral synergies	Establishment of a regular meeting system, implementation of funding for implementation, collaboration between industry associations, multisectoral collaboration to promote the division of financial and expenditure responsibilities, and multisectoral linkage and coordination mechanisms	136
10	Organizational	Hospital housekeeping	Enhanced cost accounting, data-based evidence-based hospital operations management, hospital culture development, internal compensation system, presidential accountability, internal hospital management decision-making	248
11	dimensions	Policy dissemination mechanism	Issued by a single local department, issued by the Ministry of Finance, issued by multiple local departments, coordinated by a joint meeting, issued by the State Council, issued by the Ministry of Health	173
12		Resource allocation	"Dayangwei" Specialty and Disease Alliance, Guangdong Province "Peak Plan", Hubei Shizhen Laboratory, Beijing-Tianjin-Hebei Cooperative Development, Climbing Plan, Thousands of Counties Project, Cultivation Project of Chinese Medicine Advantages	349
13		laws and regulations	Promoting the division of financial and expenditure responsibilities, revision of regulations in the field of health, intellectual property rights related to traditional Chinese medicine, and sound quality and safety regulations	10
14	Institutional	incentive mechanism	Increase research funding and achievement rewards, "two allowances", "safe hospital" construction, medical ethics assessment, improve performance appraisal system, performance pay and incentive subsidies, drug procurement constraints and incentives.	154
15	dimension	Monitoring and evaluation mechanisms	Recognition mechanism, monitoring and early warning by CDC agencies, effect feedback mechanism, comprehensive statistical system of Chinese medicine, internal audit supervision of hospitals, food safety risk monitoring and assessment, and whole-process regulation	170
16		Policy coherence	Continuation of local policies, consistency in performance appraisal, based on local-central linkage policies, based on relevant central policies	144

4.3 Social Network Analysis Process

The keyword network mapping consists of 170 edges and 158 nodes, with each node representing a dimension or sub-dimension. Node size denotes policy frequency, and edge thickness reflects co-occurrence intensity [12]. The four core dimensions—social, technological, organizational, and institutional—function as central nodes with varying concentrations(Fig. 3). For example, institutional nodes focus on healthcare management (e.g., regulation updates, salary systems), while organizational nodes involve healthcare institution layouts and personnel management. Gephi analysis shows an average degree of 2.152 (sparse connectivity), network diameter of 5 (efficient information flow), graph density of 0.014, modularity of 0.619 (distinct community structure), and average path length of 3.947. The network features decentralized connectivity but ensures efficient information dissemination[12].

5 Findings of the Study

5.1 Results of Nvivo Three-level Coding Analysis

As shown in Table 3 Coding of disciplines in public hospitals, "talent support" (346 references) and "patient demand" (241 references) dominate the social dimension (89%), reflecting key challenges such as brain drain, inadequate doctor-patient interaction, structural imbalances in medical training, weak family doctor services, and lack of hierarchical diagnosis mechanisms. In technology, "informatization tools" (142 references) and "data sharing" (70 references) are prominent but weakly linked to societal needs (e.g., "data sharing-patient demand" weight: 126), alongside issues like poor system compatibility, data security risks, and low research conversion rates (Table 3).

On Organizational Dimension, "Resource allocation" (349 references) and "policy issuance mechanisms" (173 references) highlight redundant resource distribution and insufficient policy synergy. "Internal hospital management" (248 references, 27% of the dimension) reflects homogenized regional medical resource allocation, imprecise policy implementation, and inefficient hospital administration.

On Institutional Dimension, "Policy coherence" (144 references) and "incentive mechanisms" (154 references) indicate static institutional design with poor dynamic adaptability. Additionally, "monitoring and evaluation mechanisms" (170 references) reveal weak policy oversight and misalignment between incentives and industry needs.

5.2 Results of Gephi Social Network Analysis

Based on Gephi network analysis metrics—graph density (0.014, approaching 0 for high sparsity) and average path length (0.947)—this study confirms significant small-world network characteristics in social networks, defined by larger clustering coefficients and shorter average path lengths than equivalent stochastic networks. This model is shown to enhance information transfer efficiency among network members, with specific validations as follows(Fig. 4):

Average path length of a randomized network:

$$L_{\text{random}} \approx \frac{\ln N}{\ln \langle k \rangle} = \frac{\ln 158}{\ln 2.152} = 4.5$$

Fig. 4. Calculation of the average path length of a randomized network

Comparing the average path length of the randomized network: the actual average path length (3.947) < the predicted value of the randomized network (4.5), the network has a shorter average path, which is consistent with the small-world property. In the overall network structure, the modularity value measures the strength of the community structure, and a modularity value of 0.619 (usually between 0.3 and 0.7, with a high value implying significant community structure) indicates that there is significant community structure in the network, with a strong connection within the technological dimension, but less connection with the social and institutional dimensions, resulting in the formation of "technological silos".

Nvivo analysis reveals that the core challenge in public hospital discipline construction lies in the lack of synergy among the four dimensions, necessitating systematic optimization to break through bottlenecks like "policy fights" and "technical silos". Social network analysis quantifies the small-world nature of this construction, highlighting the impacts of "fragmented top-level design" and "insufficient multidisciplinary synergy". In the social dimension, disciplinary cross-integration is an inevitable trend: dominant disciplines should lead collaborative development of related fields, while disadvantaged ones seek breakthroughs with external support; advantageous disciplines should cooperate with top domestic and foreign counterparts to introduce advanced technologies and management experience, enhance influence, and strengthen grassroots collaboration for high-quality resource sinking to realize hierarchical diagnosis and two-way referral, alongside improving assessment incentives by linking disciplinary effectiveness to hospital performance, staff remuneration, and title evaluations. In the organizational dimension, it is essential to optimize management structures, clarify departmental roles, strengthen interdepartmental synergy, establish dynamic adjustment mechanisms, and timely align discipline strategies and resource allocation with assessment results to ensure goal realization.

6 Discussion of Results

Using social-technical systems theory, this paper systematically reviews policy texts on China's public hospital discipline construction. Via Nvivo three-level coding and social network analysis, it categorizes issues into four dimensions: social, technical, institutional, and organizational.

6.1 Social Dimension: Innovative Disciplinary Synergy Model, Breaking Disciplinary Barriers

China's healthcare system faces structural talent imbalances and a weak hierarchical diagno-sis/treatment network, necessitating urgent reform of public hospital talent cultivation and resource allocation. Institutional innovation is crucial to reshape disciplinary synergy, integrating talent de-velopment with technological innovation.

First, to address faulty talent echelons, the "Four New" initiative breaks undergraduate education boundaries, fostering high-level innovative talent through enhanced interdisciplinary training. Poli-cy-guided "special interdisciplinary zones" and project-based collaboration in clinical re-search/services are recommended. For example, Fudan University Cancer Hospital's precision oncol-ogy platform transcends departmental silos, improving liver cancer early detection rates and catalyz-ing joint development of intelligent diagnostic imaging.Second, tackling hierarchical diagnosis ob-stacles, Fuwai Hospital's Cardiovascular Innovation Consortium exemplifies success. Integrating multiple institutions and enterprises via a data-sharing platform, it facilitated numerous multicenter clinical trials, accelerating domestic biodegradable stent R&D. 30.This demonstrates that breaking disciplinary/institutional barriers releases innovation efficiency and promotes resource alloca-tion.Third, for research translation bottlenecks, a policy-guided "commanding officer list" mecha-nism is proposed. Opening clinical databases and establishing IP sharing pools would enhance medi-cal service quality and translational efficiency. Institutionalizing such models can build a synergistic "basic discovery-clinical validation-industrial translation" network, systematically improving service quality and resource utilization efficiency.

6.2 Technical Dimension: Enhance Data Sharing and Establish a Dynamic Monitoring and Evaluation System

To tackle medical data fragmentation, low research utility, and insufficient monitoring, a dynamic multi-dimensional data platform is vital for supporting public hospital disciplinary policies.

First, implement national unified medical data coding standards and enforce interoperability compliance. Establish blockchain-based regional data exchanges with smart contracts for traceable cross-institutional access. Second, enhance research data utility via structured governance: mandate standardized collection templates and deploy NLP for unstructured data processing (EHRs, imaging reports), enabling federated analysis without data transfer. Third, develop a specialty monitoring platform integrating real-time EHR and research data: trigger automated alerts for DRG groups below baseline for ≥3 months, complemented by annual expert assessments linked to resource allocation (e.g., targeted psychiatry funding for regional gaps). Case in point: Renji Hospital's "municipal-district twinning" program standardized endoscopic training, improving regional IBD treatment compliance.

This closed-loop system—merging quantitative monitoring, qualitative assessment, and policy iteration—addresses traditional evaluation flaws: data latency, narrow indicators, and disjointed remediation.

6.3 Organizational Dimension: Optimizing the Policy Release Mechanism and Enhancing the Efficiency of Resource Allocation

To tackle structural inefficiencies—cross-sectoral coordination gaps, resource misallocation, and specialty homogenization—an integrated "policy-resource-evaluation" governance mechanism is essential.

First, policy synergy must be enhanced through multisectoral collaboration (finance, education, HR) in formulation. Germany's "dual system" vocational education model exemplifies how interdepartmental cooperation ensures policy viability and effectiveness. Second, resource allocation should adopt demand-driven models. The Peking Union Medical College Hospital's Medical Innovation Consortium demonstrates this via a "demand-R&D-application" , enabling precise resource matching—evident in its rare disease research coordination. Third, standardized evaluation metrics combat specialty homogenization. The tripartite-developed Specialty Capability Star Standards facilitate regional stratification, while "one hospital, one feature" plans transform homogenized institutions.

This integrated framework enhances policy coherence, curbs resource duplication, and drives specialty differentiation.

6.4 Institutional Dimension: Strengthening Top-Level Design and Formulating Coherent Discipline Development Planning

China's public hospital disciplinary development faces significant policy fragmentation and cross-departmental duplication, hindering systematic strategic planning. Evidence shows >60% policy overlap across departments over five years, lacking clear implementation pathways and causing resource inefficiency.Implement national top-down planning through a multi-ministerial "Ten-Year Discipline Development Plan" (led by National Health Commission with Education/Science ministries), modeled after Germany's Medical Excellence Program. This framework should establish sequential priorities: foundational support for core disciplines (Years 1-3), cross-disciplinary advancement (Years 4-8), and comprehensive evaluation (Years 9-10).Enhance policy coordination via institutional mechanisms like Zhejiang's "medical policy sandbox" – a multisectoral simulation platform (integrating health, insurance, and finance) that prevents fragmentation through systematic testing.This integrated approach ensures policy coherence, reduces duplication, and aligns resource allocation with long-term institutional goals.

7 Conclusion

Public hospital discipline construction is the core driving force for high-quality development and the key to implementing the Healthy China initiative. Incorporating the multidimensional dynamic framework of social-technical systems theory into hospital discipline construction provides a new method for revealing the interaction of subsystems in complex systems. This framework not only provides theoretical support for addressing discipline challenges, but also offers policymakers actionable strategies,

promoting sustainable development, enhancing discipline capabilities, and driving public hospitals to achieve high-quality development.

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