Policy Effect Evaluation of Digital Empowerment of General-Specialist Collaboration on Hypertension Management Capacity in Community Health Service Institutions: A Postprint Study

Authors: Zhao Jie, Wang Yijing, Liu Gang, Han Xinxin, Liu Gang, Han Xinxin

Date: 2025-07-29T09:17:54+00:00

Abstract

Background: In accordance with the deployment of integrated medical and preventive services, and building upon the foundation of basic public health services, Longhua District of Shenzhen launched a pilot program of "digitalization + health management" generalist-specialist collaborative services across the district in January 2022. Through digital empowerment of the collaboration and integration between primary care general practitioners and hospital specialists, the initiative aimed to improve the intra-regional consultation rates and standardized management rates for chronic disease patients.

Objective: To evaluate the policy implementation effects of the general practitioner-specialist collaborative service model under digital empowerment in enhancing the hypertension management capacity of primary healthcare institutions, and to provide evidence for policy optimization and promotion decisions.

Methods: This study employed a quasi-natural experimental design, using 532 community health service institutions operating in Shenzhen between 2021 and 2024 as the research subjects. Eighty-four institutions within Longhua District were designated as the experimental group, while the remaining 448 institutions not affected by this policy intervention served as the control group. The experimental group implemented a digital generalist-specialist collaborative service model for managing hypertension patients starting from January 2022, while the control group provided routine health management services for hypertension patients in accordance with the requirements of the "National Basic Public Health Service Standards (Third Edition)". Using inverse probability weighting, a difference-in-differences regression model was constructed to analyze differences in various management indicators between the experimental and control

groups before and after policy implementation, with robustness tests conducted to verify the reliability and stability of the model.

Results: After the implementation of the digital generalist-specialist collaborative policy pilot, compared with the control group and after controlling for other relevant factors, the standardized management rate of hypertension in the experimental group institutions increased by an average of 4.3 percentage points per quarter (DID coefficient=0.043, SE=0.011, P<0.001), the blood pressure control rate in the managed population increased by an average of 11.5 percentage points per quarter (DID coefficient=0.115, SE=0.012, P<0.001), the number of upward referrals for patients under management decreased by an average of 17.1% per quarter (P=0.038), and the total number of consultations increased by an average of 22.1% (P=0.003).

Conclusion: The implementation of digital generalist-specialist collaboration significantly enhanced the standardized management level of hypertension in community health service institutions in the experimental group, improved health outcomes in the managed population, effectively reduced the number of upward referrals for patients under management, and simultaneously promoted primary care consultation volume through policy spillover effects, playing an important role in improving the tiered diagnosis and treatment system. Future efforts may include improving policy mechanisms and establishing standardized implementation pathways to provide references for the comprehensive promotion of digital generalist-specialist collaborative services, thereby facilitating the advancement of equitable and high-quality development of basic public health services.

Full Text

Effect of Digitally Enabled Generalist-Specialist Collaborative Care on Hypertension Management Capacity at Community Health Centers in China: A Difference-in-Differences Analysis

ZHAO Jie[1], WANG Yijing[2], LIU Gang[2], *HAN Xinxin*[1]

[1]School of Public Health and Emergency Management, Southern University of Science and Technology, Shenzhen 518055, China
[2]Shenzhen Center for Disease Control and Prevention, Shenzhen 518000, China

Corresponding authors: LIU Gang, Chief Physician; E-mail: sliugang@163.com
HAN Xinxin, Assistant professor/Doctoral supervisor; E-mail: hanxx@sustech.edu.cn

Abstract Background In January 2022, Longhua District, Shenzhen piloted a digitally enabled generalist and specialist collaborative care model to deliver consistent, continuous services for patients with chronic conditions managed in community health centers. This system-level initiative integrated hospital-based specialists and community-based general practitioners through a vertically aligned care model supported by a shared digital platform. **Objective** To evaluate the

effect of this digitally enabled generalist-specialist collaborative care model on hypertension management capacity at community health centers. **Methods** We employed a difference-in-differences approach to examine changes in center-level outcomes before and after the model was implemented during 2021-2024. The treatment group included 84 health centers in Longhua District, and the comparison group included 448 health centers in the remaining districts that were not influenced by the policy. Health centers in the treatment group used the collaborative care model to deliver follow-up services, whereas health centers in the comparison group continued to provide routine services in accordance with the National Basic Public Health Service Standards (Third Edition) protocol. Multivariate linear regression with district and time fixed effects was constructed, controlling for health center characteristics and adjusting for inverse probability of treatment weights, with standard errors clustered at the center level. Robustness checks were conducted to evaluate the reliability and stability of the model. **Results** After the implementation of the digitally enabled collaborative care model, compared to centers in comparison groups, on average, quarterly standardized hypertension management rate and hypertension control rate in the treatment group increased by 4.3-percentage-point (DID=0.043, SE=0.011, P<0.001) and 11.5-percentage-point increase (DID=0.115, SE=0.012, P<0.001) per center, respectively. On average, the quarterly number of upward referrals per center decreased by 17.1% (P=0.038), and the quarterly number of total patient visits per center increased by 22.1% in the treatment group (P=0.003), as compared to comparison groups. **Conclusion** Our study highlights the significance of the digitally enabled specialist and generalist collaborative care model in enhancing health center capacity in patient management, reducing unnecessary referrals, and optimizing resource utilization. Our study underscores the importance of incorporating this initiative into national health strategies, such as the National Basic Public Health Services Program, to strengthen chronic care management services delivery in more areas of China. Future policies and research should focus on scaling up this approach to a broader range of medical conditions and prioritizing investments in health centers by ensuring stable funding streams and optimizing the implementation strategies for digital integration pathway.

[**Key words**] Public health; National essential public health services programs; Hypertension management; Generalist-specialist collaborative care; Digitally enabled; Policy evaluation

Introduction

Hypertension represents one of the most common chronic diseases in China, and its standardized management rate and control rate constitute important indicators for achieving the strategic goals of the Healthy China Initiative [1]. According to the ten-year evaluation report of the National Essential Public Health Services Program, China's standardized management rate for hypertensive pa-

tients at the primary care level reached 74.4% in 2019, with a blood pressure control rate of 67.7% among the managed population [2]. Further improving chronic disease management levels and primary healthcare service capacity represents a critical challenge for the equalization and high-quality development of national essential public health services. Digitally enabled generalist-specialist collaborative care, which efficiently integrates hospital specialist resources into primary care settings, plays a vital role in enhancing diagnostic and treatment capabilities and health management capacity at community health institutions [3]. The *National Guidelines for Primary Hypertension Prevention and Management (2020 Edition)* explicitly states that generalist-specialist management teams should be established, encouraging specialists from higher-level hospitals to join general practitioner teams to provide professional guidance [4]. Currently, various regions including Beijing, Shanghai, and Shenzhen have conducted exploratory practices of generalist-specialist collaboration at different levels [5-7].

In alignment with the medical-prevention integration deployment, and building upon the foundation of essential public health services, Longhua District in Shenzhen launched a pilot program of "digitalization + health management" generalist-specialist collaborative services across the district in January 2022. Through digital empowerment of collaboration between community generalists and hospital specialists, the initiative aimed to improve regional consultation rates and standardized management rates among chronic disease patients. The digitally enabled generalist-specialist collaborative model added the following components to the original basic public health services: (1) establishing an information database for hypertensive patients, enabling automatic identification and enrollment of patients with unstable blood pressure through big data monitoring, and facilitating information sharing across different levels of medical institutions and physicians; and (2) establishing a tightly integrated medical consortium-based generalist-specialist team, where general practitioners conduct follow-up management according to basic public health service standards, while specialists complete post-consultation reviews for enrolled patients through the generalist-specialist collaborative platform and jointly formulate management plans with general practitioners, who then execute and are responsible for subsequent follow-up management. Over the three years since policy implementation, big data monitoring has covered 91,524 hypertensive patients under management at the primary care level, with 117,159 consultations for patients with unstable blood pressure enrolled in the database. Both consultation completion rates and post-consultation execution rates have exceeded 97%, demonstrating initial success [8].

In this context, our study employs a quasi-natural experimental design, using community health service institutions in Shenzhen as research subjects, with indicators including standardized hypertension management rate, blood pressure control rate, upward referral frequency, and total patient visits. Through constructing a difference-in-differences regression model, we evaluate the policy implementation effects of the digitally enabled generalist-specialist collaborative

service model in enhancing hypertension management capacity at primary care institutions, providing evidence for policy optimization and promotion decisions.

Methods

Study Subjects

This study utilized community health service institutions operating in Shenzhen between 2021-2024 as research subjects. Exclusion criteria included: (1) institutions whose operation period did not span the policy implementation time point; and (2) institutions with fewer than 50 enrolled hypertensive patients. Since Bao'an District was also exploring generalist-specialist service models during the study period and could confound results, it was excluded [9]. Ultimately, 532 community health service institutions across Shenzhen were included in the study sample.

Given that the digitally enabled generalist-specialist collaboration was piloted in Longhua District starting January 2022, all 84 institutions within Longhua District were designated as the treatment group, while the remaining 448 institutions not affected by the policy intervention served as the control group. The treatment group implemented the digitally enabled generalist-specialist collaborative service model for managing hypertensive patients after January 2022, whereas the control group continued providing routine health management services according to the *National Basic Public Health Service Standards (Third Edition)*.

Indicator Selection

This study examined the impact of the digitally enabled generalist-specialist collaborative policy pilot on standardized hypertension management rate, blood pressure control rate among the managed population, upward referral frequency, and total patient visits at community health service institutions. Following the definitions in the *National Basic Public Health Service Standards (Third Edition)*, standardized hypertension management rate was calculated as: (number of hypertensive patients managed according to protocol / number of hypertensive patients under management in the quarter) × 100%. Blood pressure control rate among the managed population was calculated as: (number of patients with blood pressure at target at the most recent follow-up in the quarter / number of hypertensive patients under management in the quarter) × 100%, with blood pressure control target defined as systolic blood pressure <140 mmHg and diastolic blood pressure <90 mmHg (for patients aged 65 and older: systolic blood pressure <150 mmHg and diastolic blood pressure <90 mmHg). In addition to analyzing direct effects on managed hypertensive patients, this study also assessed spillover effects of the policy pilot on overall consultation volume at community health service institutions. To ensure normal distribution of upward referral frequency and total patient visits, natural logarithms (ln) were

taken for these indicators. For easier interpretation, regression coefficients were transformed using elasticity formulas, with the relative change rate in the treatment group after policy implementation calculated as $(\%\Delta y) = (e^{\hat{}}\beta - 1) \times 100\%$.

Statistical Methods

Inverse Probability of Treatment Weighting (IPTW) To control for potential systematic differences between treatment and control groups and reduce confounding bias, this study employed IPTW to balance differences across all observable covariates between groups, thereby more accurately estimating the average treatment effect (ATE) of the policy intervention on management outcomes. The fundamental principle of IPTW is to construct weights based on the inverse of the probability (propensity score) that an individual receives their actual treatment status, enabling weighted samples to achieve inter-group balance in covariate distribution and simulating a "random allocation" scenario.

Based on baseline characteristics of community health centers in 2021, we constructed a propensity score model with covariates including: proportion of patients aged 65 and older, proportion of female patients, years of operation, proportion of licensed physicians, proportion of equipment valued over 100,000 RMB, proportion of fiscal appropriation income, number of enrolled hypertensive patients, and registration type. Model estimates were used to calculate the probability of each institution being assigned to the treatment group (propensity score). Subsequently, inverse probability weights (IPTW) were calculated for each institution based on its treatment status and propensity score using the following formulas:

If institution belongs to treatment group: IPTW = 1 / [propensity score (probability of receiving policy intervention)]

If institution belongs to control group: IPTW = 1 / (1 - propensity score)

To improve estimation stability, we applied stabilized weights by adjusting the numerator to the overall proportion of treatment/control groups, making the mean weight close to 1. Additionally, we trimmed extreme weights exceeding the 99th percentile to reduce the influence of outliers on estimation results.

This study also used propensity score matching (PSM) for pairwise matching, yielding results consistent with the IPTW method. Given that IPTW maximally preserves original sample information, enhances real-world representativeness, and improves estimation efficiency, we primarily report IPTW-based estimates. Compared to PSM, IPTW offers several advantages: (1) it weights based on the full sample without discarding observations, improving statistical power and estimation efficiency; (2) it is more suitable for regression modeling and ATE estimation, and can be combined with covariate adjustment methods to form doubly robust estimators, commonly used in public policy evaluation and external inference [10]; and (3) it directly constructs weights based on propensity

scores, providing a smooth, robust method that reduces reliance on subjective parameters (such as matching radius or number of neighbors) and avoids matching error bias [11].

Difference-in-Differences (DID) Method We employed the commonly used policy evaluation method—DID—to treat the Longhua District digitally enabled generalist-specialist collaborative policy pilot as a quasi-natural experiment. All institutions within Longhua District served as the treatment group, while institutions in other administrative districts not affected by the policy served as the control group. After controlling for other relevant factors, we compared differences in management indicators between treatment and control groups before and after policy implementation to obtain the net policy effect.

Based on data quality and availability, we collected hypertension management data from Shenzhen community health service institutions from 2021-2024, organized as institution-quarter panel data. The study period comprised 16 quarters across 532 institutions, totaling 8,258 observations. Using the first quarter of 2022 as the policy implementation time point, we defined the pre-implementation period as Q1 2021 to Q4 2021 and the post-implementation period as Q1 2022 to Q4 2024. We constructed the following DID model, controlling for quarter and district fixed effects to minimize the impact of temporal trends and inter-regional differences on estimation results:

y_{i,t} = α_0 + β_1 treated_i + β_2 post_t + β_3 treated_i × post_t + β_4 control_{i,t} + γt + _i + {i,t} (1)

Where y_{i,t} represents the outcome variable for institution i at time t. treated_i is a group variable assigned as 1 for treatment group institutions and 0 for control group institutions. post_t is a time dummy variable, with Q1 2022 to Q4 2024 coded as 1 (post-implementation) and Q1 2021 to Q4 2021 coded as 0 (pre-implementation). treated_i × post_t is the DID interaction term used to estimate the effect of the digitally enabled generalist-specialist collaborative service model. control_{i,t} includes control variables such as proportion of patients aged 65 and older, proportion of female patients, years of operation, proportion of licensed physicians, proportion of equipment valued over 100,000 RMB, proportion of fiscal appropriation income, number of enrolled hypertensive patients, and registration type. *γt and _i represent quarter and district dummy variables (time and district fixed effects), respectively, and* {i,t} is the random error term. β_3 is the DID estimate coefficient and the primary effect value of this study, reflecting the impact of policy implementation on hypertension management effectiveness at community health service institutions.

Recognizing that observations from the same institution across different quarters may exhibit temporal correlation (clustering of error terms within centers), we clustered standard errors at the institution level to avoid underestimating standard errors and obtain robust inference results, thereby controlling for bias

from repeated measurements.

Based on propensity score estimation, we applied inverse probability weights to the overall regression model to obtain treatment effect estimates adjusted for IPTW [10].

Robustness Checks We employed event study methodology to test the parallel trends assumption of the DID model, examining whether outcome variable trends were consistent between treatment and control groups before policy implementation. If the parallel trends assumption holds, it indicates comparability between groups before intervention, thereby enhancing the internal validity of DID estimates. Additionally, event study analysis can characterize the temporal dynamic effects of policy intervention, identifying whether hypertension management effects strengthen over time, while partially excluding confounding bias from temporal changes or unobserved institutional characteristics.

The event study baseline regression model is as follows:

y_{i,t} = α_0 + Σ_{s=1}^{D-2} *β{pre}^s × time_s × treated_i* + *Σ*{s=1}^{+∞} *β*_{post}^s × time_s × treated_i + *γt* + *_i* + {i,t} (2)

Compared to equation (1), equation (2) adds time_s dummy variables representing period s, where time_D is the policy implementation period. *β{pre}^s reflects differences between treatment and control groups before the policy time point, while* *β*{post}^s reflects differences after the policy time point. If the parallel trends assumption holds, *β*_{pre}^s coefficients should not be significantly different from 0.

To further verify the robustness and credibility of policy effects and test for potential bias from temporal trends or unobserved institutional characteristics, we also conducted placebo tests. Specifically, we randomly selected 200 institutions from the 532 included samples as "pseudo-treatment groups," constructed pseudo-intervention variables, and repeated the simulation 1,000 times, recording the distribution of interaction term coefficient estimates from each simulation to compare whether the actual estimate falls in the extreme tail of the simulated distribution.

Statistical Software

This study used Stata 18.0 for analysis, with $P<0.05$ considered statistically significant.

Results

Balance Test

To examine balance in baseline covariates between treatment and control groups after propensity score weighting, we used standardized mean differences (SMD) for covariate balance testing. Generally, an absolute SMD <0.1 indicates good balance in variable distribution between treatment and control groups, with SMD values closer to 0 representing better balance.

As shown in , before weighting, some covariates showed significant differences between treatment and control groups. After weighting, standardized differences for all covariates were <0.1, indicating that inter-group distributions became consistent and achieved good covariate balance. The standardized difference plot shows that SMDs for covariates were substantially reduced after weighting, validating the effectiveness of inverse probability weighting in achieving inter-group balance ([Figure 1: see original paper]).

Descriptive Statistics

As presented in , before implementation of the digitally enabled generalist-specialist collaborative service model, the treatment group had a mean standardized hypertension management rate of 71.8% and a mean blood pressure control rate of 69.5%. After policy implementation, the standardized management rate was 71.9% and the blood pressure control rate was 81.4%. The control group showed no increase in either hypertension standardized management rate or blood pressure control rate among the managed population. After policy implementation, both average upward referral frequency and total patient visits increased in the treatment group.

DID Model Estimates

As shown in , after implementation of the digitally enabled generalist-specialist collaborative policy and controlling for other relevant factors, the standardized hypertension management rate in treatment group institutions increased by an average of 4.3 percentage points per quarter compared to control groups (DID coefficient=0.043, SE=0.011, P<0.001), representing a 6.9% increase relative to the pre-pilot overall management rate (62.1%). The blood pressure control rate among the managed population in treatment group institutions increased by an average of 11.5 percentage points per quarter compared to control groups (DID coefficient=0.115, SE=0.012, P<0.001), representing a 15.5% increase relative to the pre-pilot overall blood pressure control rate (74.1%).

Additionally, after policy implementation, the natural logarithm of quarterly upward referral frequency per center in treatment group institutions decreased by an average of 18.7 percentage points compared to control groups (DID coefficient=-0.187, SE=0.090, P=0.038), while the natural logarithm of total patient visits increased by an average of 20 percentage points (DID coeffi-

cient=0.200, SE=0.067, P=0.003). Using elasticity formula to transform regression coefficients, this is interpreted as treatment group institutions experiencing an average 17.1% decrease in quarterly upward referral frequency and a 22.1% increase in total patient visits.

Parallel Trends Test Results

To avoid multicollinearity, we set the quarter immediately before policy implementation as the baseline period and excluded this period's dummy variable from the model. "0" indicates the policy implementation quarter, while "-t" and "+t" represent time points t quarters before and after policy implementation, respectively. As shown in [Figure 2: see original paper], before policy pilot implementation, the four outcome indicators showed similar average growth trends between treatment and control groups, with most pre-intervention period dummy variable regression coefficients being non-significant, supporting the parallel trends assumption. After policy implementation, blood pressure control rate among the managed population began showing a significant upward trend from the fourth quarter post-implementation, while upward referral frequency showed a clear downward trend from the second quarter onward. This indicates that the positive effects of the digitally enabled generalist-specialist collaborative service model on hypertensive patients' health outcomes gradually emerged within one year after policy implementation, with certain lag and persistence in intervention effects.

Placebo Test Results

As shown in [Figure 3: see original paper], estimated coefficients under pseudo-treatment groups were mostly concentrated around 0, showing no significant difference compared to baseline regression results, indicating that the true policy intervention effect was not due to random error or unobserved factors.

Discussion

Digitally Enabled Generalist-Specialist Collaboration Enhances Standardized Hypertension Management at Primary Care Level

The *National Basic Public Health Service Standards (Third Edition)* clearly requires providing at least four face-to-face follow-up visits and health examinations annually for patients with primary hypertension [14]. Our study results demonstrate that digitally enabled generalist-specialist collaboration significantly improved standardized hypertension management at community health institutions. By establishing a digital health information platform, the model enabled full-process tracking from patient diagnosis and treatment to follow-up, facilitating supervisory oversight of implementation and timely guidance on standardized management compliance [15]. Simultaneously, the system's au-

tomatic reminders for general practitioners to complete patient tracking and follow-up tasks enhanced the proactivity and timeliness of patient management at primary care institutions, helping general practitioners more efficiently fulfill requirements of the national essential public health service standards [16].

Digitally Enabled Generalist-Specialist Collaboration Improves Health Outcomes Among Managed Hypertension Population

The *National Basic Public Health Service Standards (Third Edition)* states that patients with unsatisfactory blood pressure control, severe adverse drug reactions, or complications should be referred promptly, with follow-up on referral status within two weeks. Our study results show that digitally enabled generalist-specialist collaboration significantly improved health outcomes among the managed hypertension population, with better blood pressure control and significantly reduced upward referrals, representing important implications for conserving medical resources. On one hand, the digital platform enabled interactive collaboration between community general practitioners and hospital specialists, allowing higher-level physicians to provide guidance on complex cases and assist generalists in managing patients with unstable conditions, thereby improving primary care institutions' diagnostic and treatment capacity [17]. On the other hand, real-time monitoring of patients' blood pressure and medication adherence through big data enabled timely intervention for high-risk patients, while seamless information flow of patient conditions, medication records, and diagnostic information ensured service continuity and improved treatment effectiveness, playing a crucial role in enhancing blood pressure control levels among the managed population [18].

Digitally Enabled Generalist-Specialist Collaboration Promotes Improvement of Tiered Healthcare System

Our findings also indicate that the digitally enabled generalist-specialist collaborative policy generated significant spillover effects, not only effectively reducing upward referral frequency for hypertensive patients under management (helping retain more patients at the primary care level) but also promoting growth in total consultation volume at community health service institutions, representing important contributions to improving the tiered healthcare system. Through information integration, patients could meet most of their healthcare needs at the primary care level, reducing the time and economic burden of traveling to larger hospitals, improving patient compliance and service satisfaction, and facilitating smoother implementation of primary care first-contact and two-way referral systems. After resource optimization, patients completed blood pressure monitoring and follow-up management at the primary care level, while information about patients with unstable conditions was promptly fed back to higher-level hospital specialists through the platform, promoting efficient collaboration with vertical integration and acute-chronic disease separation [19].

Study Limitations

This study has several limitations. First, we used institution-level longitudinal administrative data. Although we employed a quasi-experimental design, the data nature remains observational rather than experimental. We constructed a difference-in-differences fixed-effects model using inverse probability weighting to improve estimation accuracy and enhance credibility of causal associations between policy implementation and outcome indicators. Second, although the DID method can control for time-invariant factors affecting outcome indicators, estimation results may still be influenced by omitted variables such as patient case mix or other related policies (such as medical-prevention integration). We verified the stability and reliability of our findings through parallel trend tests and multiple robustness checks, with results showing consistent conclusions across different model specifications or external condition changes without substantial deviation.

Policy Implications

Leveraging the National Essential Public Health Services Platform to Provide Sustainable Policy Support for Generalist-Specialist Collaboration

To promote sustained development of generalist-specialist collaborative management, policy guidance and support are crucial. As a systematic, foundational institutional arrangement at the national level, the high-quality development needs of essential public health services provide policy opportunities and important support for generalist-specialist collaboration [20]. Generalist-specialist collaborative management should continue to rely on essential public health services, introducing higher-level specialist resources to enhance primary care capacity. This not only promotes primary healthcare development but also provides clear policy basis and direction for implementing generalist-specialist collaborative services. In addition to service content collaboration, management mechanism linkage cannot be overlooked. Essential public health service project subsidy funds have become one of the main sources of primary care fiscal subsidies. Through payment method reforms and optimized performance evaluation systems, we should stimulate the enthusiasm and initiative of primary generalists and higher-level specialists, forming stable and effective operational mechanisms to promote sustainable development of the generalist-specialist collaborative model [2].

Fully Utilizing Digital Empowerment to Provide Technical Support for Primary Chronic Disease Health Management

Unlocking the potential of digital technology represents a key pathway to improving generalist-specialist collaborative service quality. First, we should

strengthen the construction of digitally enabled generalist-specialist service pathways, promoting innovation and development of health management service models. By enhancing collaborative efficiency among service entities, enriching service content diversity, and promoting intelligent transformation of health decisions, we can comprehensively reshape the collaboration model between generalists and specialists [21]. Simultaneously, we should continuously optimize digital elements based on practical needs to ensure flexibility and adaptability of service pathways and management models. This requires focusing on key aspects such as information platform construction, user interaction, and work feedback to create user-friendly, convenient information management platforms that comprehensively promote innovative development of generalist-specialist collaborative management [22].

Optimizing Policy Mechanisms to Provide Institutional Guarantee for Sustainable Digitally Enabled Generalist-Specialist Collaboration

Promoting efficient operation of generalist-specialist collaboration requires robust institutional mechanisms and systemic guarantees. We should closely integrate medical consortium construction to build a clearly defined organizational system with consistent objectives through unified management mechanisms, promoting collaborative integration between primary generalists and higher-level specialist institutions to form work synergy [23]. Regarding incentive mechanism design, diversified measures such as performance rewards and professional promotion can be adopted, linking management effectiveness to performance to mobilize participation enthusiasm among general practitioners and specialists. Simultaneously, flexible feedback and adjustment mechanisms should be established for problems that may arise during policy implementation, continuously improving institutional design and implementation pathways through regular monitoring and dynamic optimization to promote continuous improvement and application expansion of the digitally enabled generalist-specialist collaborative model.

Conclusion

Based on a quasi-experimental design of the policy pilot, this study used longitudinal hypertension management data at the community health service institution level to construct econometric regression models, evaluating the effects of digitally enabled generalist-specialist collaboration on improving hypertension management effectiveness, health outcomes among managed populations, and promoting tiered healthcare. The findings indicate that implementing digitally enabled generalist-specialist collaboration significantly improved standardized management efficiency at community health institutions, enhanced health outcomes among managed populations, effectively reduced upward referral frequency for patients under management, and simultaneously retained more patients at the primary care level through policy spillover effects, playing an impor-

tant role in improving tiered healthcare. Future efforts can provide references for comprehensive promotion of digitally enabled generalist-specialist collaborative services through measures such as improving policy mechanisms and establishing standardized implementation pathways, thereby contributing to the equalization and high-quality development of essential public health services.

References

[1] Central Committee of the Communist Party of China, State Council of the People's Republic of China. "Healthy China 2030" Planning Outline [J]. Chinese Practical Journal of Rural Doctor, 2017, 24(7): 1-12.

[2] YOU Lili, ZHAO Jinhong, CHEN Xinyue, et al. Ten-year evaluation of the National Essential Public Health Services Program (2009-2019) series report (II)—Progress and achievements of the National Essential Public Health Services Program over ten years [J]. Chinese General Practice, 2022, 25(26): 3209-3220. DOI: 10.12114/j.issn.1007-9572.2022.0407.

[3] LI Zhong, ZHANG Liang, LI Haomiao, et al. Digital technology embedding, primary healthcare organizational resilience enhancement, and health service system reshaping: mechanism of action and framework [J]. Chinese Journal of Health Policy, 2024, 17(9): 36-43. DOI: 10.3969/j.issn.1674-2982.2024.09.006.

[4] National Primary Hypertension Prevention and Management Office, Primary Hypertension Management Expert Committee. National guidelines for primary hypertension prevention and management [J]. Chinese Circulation Journal, 2017, 32(11): 1041-1048. DOI: 10.3969/j.issn.1000-3614.2017.11.001.

[5] HUANG Hualei, LI Li, XU Yongqing, et al. Study on the effect of multidisciplinary joint management model on psychosomatic rehabilitation management of community diabetic patients [J]. Chinese General Practice, 2019, 22(15): 1842-1847. DOI: 10.12114/j.issn.1007-9572.2019.00.169.

[6] LIU Weifang, GE Lingyu, CHEN Xin, et al. Analysis of the application effect of the "specialist-generalist-patient" combined model in patients with resistant hypertension [J]. Shanghai Medical & Pharmaceutical Journal, 2021, 42(22): 41-44. DOI: 10.3969/j.issn.1006-1533.2021.22.012.

[7] WANG Xuling. Evaluation of the effect of community "generalist-specialist joint" comprehensive intervention on hypertensive patients with anxiety and depression [J]. Shanghai Medical & Pharmaceutical Journal, 2022, 43(20): 55-59. DOI: 10.3969/j.issn.1006-1533.2022.20.015.

[8] YAN Xinfeng, YU Chuanning, CAO Sijing, et al. Digital empowerment of generalist-specialist collaborative community chronic disease pathway management under essential public health services: practical exploration and preliminary effectiveness [J/OL]. Chinese General Practice, 2025: 1-7. (2025-07-02). https://kns.cnki.net/kcms/detail/13.1222.R.20250701.1825.006.html.

[9] LIANG Jinfeng, WANG Chao, WU Haibo, et al. Preliminary exploration of the "four-party linkage" medical and health service model—taking Shenzhen Bao'an District People's Hospital Group as an example [J]. Chinese Journal of Social Medicine, 2021, 38(2): 123-126. DOI: 10.3969/j.issn.1673-5625.2021.02.001.

[10] COLE M B, WRIGHT B, WILSON I B, et al. Medicaid expansion and community health centers: care quality and service use increased for rural patients [J]. Health Aff, 2018, 37(6): 900-907. DOI: 10.1377/hlthaff.2017.1542.

[11] CHESNAYE N C, STEL V S, TRIPEPI G, et al. An introduction to inverse probability of treatment weighting in observational research [J]. Clin Kidney J, 2022, 15(1): 14-20. DOI: 10.1093/ckj/sfab158.

[12] WANG Huiling, KONG Rong. Does formal borrowing promote consumption of rural households?—Empirical analysis based on PSM method [J]. Chinese Rural Economy, 2019(8): 72-90. DOI: 10.20077/j.cnki.11-1262/f.2019.08.005.

[13] DESHPANDE M, LI Y. Who is screened out? application costs and the targeting of disability programs [J]. Am Econ J Econ Policy, 2019, 11(4): 213-248. DOI: 10.1257/pol.20180076.

[14] National Health and Family Planning Commission. Notice on issuing the *National Basic Public Health Service Standards (Third Edition)* [J]. Gazette of the National Health and Family Planning Commission of the People's Republic of China, 2017(3): 21.

[15] BATES D W, BITTON A. The future of health information technology in the patient-centered medical home [J]. Health Aff, 2010, 29(4): 614-621. DOI: 10.1377/hlthaff.2010.0007.

[16] BAI Xue, ZHU Yu. Design and application of regional chronic disease monitoring system under big data background [J]. Chinese Journal of Health Informatics and Management, 2024, 21(6): 895-901. DOI: 10.3969/j.issn.1672-5166.2024.06.017.

[17] JIA W P, ZHANG P H, ZHU D L, et al. Evaluation of an mHealth-enabled hierarchical diabetes management intervention in primary care in China (ROADMAP): a cluster randomized trial [J]. PLoS Med, 2021, 18(9): e1003754. DOI: 10.1371/journal.pmed.1003754.

[18] TUTINO G E, YANG W Y, LI X, et al. A multicentre demonstration project to evaluate the effectiveness and acceptability of the web-based Joint Asia Diabetes Evaluation (JADE) programme with or without nurse support in Chinese patients with Type 2 diabetes [J]. Diabet Med, 2017, 34(3): 440-450. DOI: 10.1111/dme.13164.

[19] SHEN X J, YANG W X, SUN S R. Analysis of the impact of China's hierarchical medical system and online appointment diagnosis system on the sustainable development of public health: a case study of Shanghai [J]. Sustainability, 2019, 11(23): 6564. DOI: 10.3390/su11236564.

[20] YOU Lili, LIU Yuanli. Ten-year evaluation of the National Essential Public Health Services Program (2009-2019): significance and experience of implementing the National Essential Public Health Services Program [J]. Chinese General Practice, 2022, 25(26): 3203-3208. DOI: 10.12114/j.issn.1007-9572.2022.0441.

[21] JIANG Weiguo, TANG Shudi. Research on digital technology enabling high-quality supply of rural essential public health services [J]. World Agriculture, 2023(5): 68-77. DOI: 10.13856/j.cn11-1097/s.2023.05.006.

[22] TANG Hao, MA Jingdong. Review of research on the formation path of patient-perceived value of community chronic disease diagnosis and treatment services in internet environment from the perspective of value co-creation [J]. Soft Science of Health, 2024, 38(10): 15-20. DOI: 10.3969/j.issn.1003-2800.2024.10.004.

[23] LI Xiaoxuan, TIAN Xin. Comparative analysis of the impact of "two medical consortium" assistance models on enhancing community health service center capacity [J]. Chinese Health Economics, 2024, 43(9):

(Received: April 10, 2025; Revised: July 5, 2025)
(Editor: MAO Yamin)

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