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# Novel use of structural equation modeling to examine the development of a framework of patient-centered two-way referral systems for building digital subjective well-being healthcare: A cross-sectional survey in Central China

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## Abstract

**Background:** Digital health technologies are progressively assuming significant roles in aspects encompassing in-hospital management, patient-centered design, and tiered referral systems. Nevertheless, current studies do not involve exploration into the potential value and mechanisms of digital health in a patient-centered context. This study aimed to explore the development of a framework of comprehensive, evidence-based digital health technologies for the construction of welfare-oriented healthcare.

**Methods:** From March to June 2023, a cross-sectional online study was performed, involving 335 respondents with prior referral experiences hailing from the Central China region. Data on welfare-oriented healthcare factors (clinical pathway management, medical structure configuration, healthcare service accessibility, two-way referrals) underwent factor analysis in advance, and correlation between these factors and their association with two-way referrals was evaluated by testing for direct and indirect (mediating) effects.

**Results:** Firstly, there existed a significant positive correlation between integrative medical indicators and welfare-centered healthcare ($\beta = 0.02–0.16$, $p < 0.05$). Furthermore, two-way referral had an direct association with integrative medical parameters and the welfare healthcare service system ($\beta = 0.15–0.31$, $p < 0.05$), but exerted a partial mediatory function in the welfare healthcare service system ($\beta = 0.005–0.021$, $\alpha < 0.05$). Two-way referrals partially mediate the integrated medical indicators, mainly through direct effects, while also providing complementary support. Clinical pathways, medical structure, and accessibility are closely linked to welfare healthcare and significantly influence healthcare quality. Thus, improving these factors should be prioritized.

**Conclusion:** This study proposes a method combining integrated evaluation indicators with pathway mechanism design. This pathway mechanism design includes key steps such as patient registration, information extraction, hospital allocation or referral, diagnosis and treatment, rehabilitation plan monitoring, service feedback, and demand resolution. This design aims to change patients' intentions in seeking healthcare, thereby increasing their acceptance of bidirectional referrals, and ultimately enhancing the effectiveness and realization of welfare healthcare.

## Keywords

Digital health, subjective well-being healthcare, patient-centered design, public health, two-way referral

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## Introduction

Since the mid-1980s, as healthcare service reforms have been extensively implemented across the globe, the provision of medical and health services in a hierarchical, diversified, and competitive manner has become a universal trend.[1] As society evolves, challenges such as the outbreak of the COVID-19 pandemic, shifts in the spectrum of disease, unbridled future costs of cancer,[2] rising healthcare resource supply costs, intensifying aging populations, and the imperative transition from intermittent treatment of acute diseases to more sustained care for chronic conditions have placed higher demands on medical establishments.[3]

The healthcare service system is inextricably tied to the subjective well-being of the populace.[4] Subjective well-being (SWB) refers to how individuals experience and evaluate their lives and specific domains and activities within their lives. It is often used as a measure of happiness and encompasses both cognitive evaluations of one's life (life satisfaction) and affective reactions to one's life (positive and negative emotions).[5] It has been the subject of extensive research in psychology and public health, with a focus on understanding its determinants and implications for individual and societal well-being. Academician Wang Chen emphasized that the concepts of "big medicine," "big health," and "big well-being," which lead and promote medical, health, and SWB initiatives, are closely correlated with national security, social stability, and the SWB of the people, as highlighted in an exclusive interview with the Journal of the Chinese People's Political Consultative Conference. In 2016, a joint research report on China's medical and health system reform was released by the World Bank (WB), the World Health Organization (WHO), China's Ministry of Finance (MOF), the former National Health and Family Planning Commission of China (NHFPC), and China's Ministry of Human Resources and Social Security (MOHRSS). One of the core recommendations in the report was to establish a patient-centered integrated care (PCIC) model. This underscores the vital practical and theoretical significance of constructing a welfare-oriented healthcare governance model based on a people-centered approach, bottom-up strategies, and multi-dimensional considerations.

Patient-centered healthcare service models are widely present in traditional healthcare, but the advent of the digital era places individuals at the core of decision-making and service provision, providing a new label for patient-centered healthcare. Despite advancements in healthcare service innovation, there is still a need to fully realize patient-centered healthcare. The digitization of healthcare systems, such as electronic health records (EHR) and 3D printing of personalized medications, shows promise but also faces challenges.[6–8] During the COVID-19 pandemic, telemedicine experienced significant growth, highlighting its adaptability. However, concerns regarding personalization and costs persist.[9–11] The majority of studies are focused on the digital transformation of personalized healthcare, while there is relatively less research on information systems specifically tailored for personalized healthcare. With the increasing advocacy and promotion of policies supporting the construction of personalized healthcare digital platforms, there is potential for the development of healthcare information systems.

Digital health literature often focuses on clinical applications, with limited attention to digitized referral mechanisms. Two-way referral is a healthcare process where patients are transferred between different levels of medical facilities based on their diagnosis and treatment needs. As an innovative service mechanism, two-way referral can be part of constructing a "patient-centered" healthcare system, helping bridge existing gaps and promoting a more comprehensive development of the healthcare welfare system.[12] Since the opening-up and reform policy in China, a series of "non-integrated" and service "fragmentation" issues have significantly hindered the implementation of two-way referral.[13] The medical alliance model faces management issues such as insufficient policy guidance, inconsistent standards, and lack of incentive mechanisms. Institutional problems include conflicts of interest, weak service capacity, and a lack of medical information sharing. Meanwhile, societal issues involve low willingness of patients to choose community primary care and insufficient information reception, among others.[14]However, the existing digital health literature primarily delves into clinical applications and electronic healthcare,[15] such as the application of machine learning (ML)/deep learning (DL) technologies in various medical fields,[16] for instance, the use of virtual reality rehabilitation landscape (VRTL) technology in clinical treatment,[17] and the design and application of clinical decision support systems and electronic nursing records.[18]The purpose of this article is to explore the construction of an information-based bidirectional referral mechanism within the framework of a healthcare alliance model.

The primary objective of this study is to investigate the impact of information construction, particularly digital referral, on the comprehensive healthcare service system. Compared to previous studies, this paper differs in two main aspects: Firstly, the study considers information construction, particularly the impact of digital referrals on the comprehensive healthcare

service system. Building on the concept of integrated delivery systems (IDS),[19] we have established a welfare-oriented healthcare quality assessment indicator system, providing theoretical groundwork and preliminary evidence for this service system. Secondly, the study proposed a method that integrates evaluation indicators and incorporates pathway mechanism design. The intermediary role of bidirectional referrals plays a crucial part in the study, and based on the analytical conclusions, recommendations and strategies are proposed for the enhancement of digital healthcare service systems.

## Research background

### Conceptual background

Welfare healthcare refers to a medical model guided by the welfare city concept, aiming to provide inclusive medical services to ensure that every citizen enjoys basic healthcare rights. Urban form and architectural environmental characteristics can bolster health and welfare in multiple ways,[20–22] such as emphasizing fairness and justice in urban planning and public service subsidies, prioritizing group needs, and providing universal public services such as education, healthcare, and social security. This concept has been further extended to the field of healthcare and has developed into the welfare healthcare model. Two-way referral is a representation of medical transparency and accessibility[23] and is also an indispensable component of the welfare healthcare system. In developing countries, referrals represent the "right to choose" for patients, contributing to the democratization of doctor–patient relationships and driving the transformation of medical services from supply-oriented to demand-oriented in the context of bidirectional selection.

### Theoretical literature

Inclusion and Exclusion Criteria: (1) Inclusion Criteria: Literature Time Frame: 1990–2023; Research Content: Healthcare quality, healthcare system evaluation, digital health; Types of Literature: Survey studies, typical case studies, current situation studies, and reviews. (2) Exclusion Criteria: Research Content: Studies unrelated to healthcare quality, healthcare system evaluation, and digital health; Types of Literature: News, letters, comments, popular science information, conference abstracts, etc. Literature Retrieval Resources: (1) Chinese and English Databases: China National Knowledge Infrastructure (CNKI), Wanfang Data, China Science and Technology Journal Database (VIP), PubMed, Semantic Scholar, and Elsevier. (2) Other Databases: Official websites such as the WHO, China Hospital Quality Evaluation Indicator System (CHQIS), International Quality Indicator Program (IQIP), Australian and Canadian healthcare quality indicators, and Health Resources and Services Administration (HRSA) were used to collect healthcare quality system evaluation indicators to form the original index database for this study. Literature Retrieval Keywords and Strategies: (1) Main Retrieval Keywords: Healthcare system, referral, digital health. (2) Literature Retrieval Strategy: Two members of the research team independently conducted the search. Search terms: "healthcare system + referral" and "healthcare system + digital health."

As shown in Table 1, we found that researchers studied the integration indicators of public health system, integration of health system, and functional integration. The integration modes of medical and health service system are diverse, mainly including vertical integration and horizontal integration[24]; functional integration, personnel integration, organizational integration, and system integration; the integration of medical care, clinical service, and medical management and concept[25]; and organization integration, management integration, and business integration.[26] Many articles have mentioned the necessity and solutions of integrating the medical system, but there is still no standard evaluation system, and the indicators are multi-level. It is necessary to establish rating indicators for a standardized integrated medical service system.

### Hypothesis development

Clinical pathway management is a management approach that optimizes medical service processes and enhances clinical healthcare quality and efficiency by developing and implementing clinical pathways.[43] Parameters such as the average length of stay (ALOS), health resource service efficiency, and bed occupancy rate have been mentioned by various authoritative health organizations including the WHO, International Quality Indicator Project (IQIP), and Chinese Medical Quality Indicator System (CHQIS), as part of their assessment criteria. Research on clinical pathway management already exists, such as data-driven personalized pathway design for different patient groups; the integration of emerging technologies such as artificial intelligence, Internet of Things, remote monitoring, and virtual healthcare to enhance the effectiveness of clinical pathways; and the utilization of quality indicators and performance assessment tools to monitor the quality of clinical pathways. Despite many studies proposing ideal models for clinical pathway management, there is insufficient implementation in practical execution, as well as challenges in standardization across institutions and regions.[27,28,44,45]

**Table 1.** Overview of the literature related to welfare healthcare.

| Author | Year | Territory | Latent variable | Independent variable | Formal evaluation |
|---|---|---|---|---|---|
| WHO[27] | 2022 | Public health | Clinical pathway management | ALO, bed occupancy rate, medical technology level, health resource service efficiency | Quantitative study |
| National Bureau of Statistics[28] | | | | | Quantitative study |
| Jalili, etc.[14] | 2018 | | Welfare healthcare, digital referral, medical structure configuration | Digital system construction satisfaction, medical quality structure, medical manpower structure | Quantitative study |
| HRSA[29–31] | 2023 | Welfare healthcare | Medical service accessibility | Coverage of medical services, number of medical service points, medical insurance, and participation mode | Quantitative study |
| Shanghai Municipal Bureau of Statistics[32] | 2020 | | Medical service accessibility | Healthcare expenditure, health insurance, and forms of participation | Quantitative study |
| Zheng Ying, etc.[33] | 2022 | Integrated medical service system | Welfare healthcare, medical structure configuration, clinical pathway management | Medical manpower structure, medical technology level | – |
| Wang Yun, etc.[34] | 2012 | | Medical structure configuration | Medical quality structure, medical manpower structure, medical material resource structure | Qualitative investigation, quantitative study |
| Ting, etc.[35] | 2020 | Welfare healthcare | Welfare healthcare, digital referral | Construction rate of sustainable health management mechanism, digital system construction satisfaction, health indicator | Qualitative investigation |
| Li, etc.[36] | 2014 | Integrated medical service system | Clinical pathway management, digital referral | Medical material resource structure, digital system construction satisfaction | Qualitative investigation |
| Black, etc.[37] | 2011 | Welfare healthcare | Digital referral | Digital system construction satisfaction, medical technology level | Qualitative investigation |
| Khan[38] | 1992 | | Medical service accessibility | Coverage of medical services, quantity of medical services | Qualitative investigation, quantitative study |
| Bouamrane, etc.[39] | 2014 | | Digital referral | Digital system construction satisfaction, professional staff service satisfaction | Qualitative investigation |
| Xu, etc.[40] | 2019 | Integrated medical service system | Welfare healthcare, medical service accessibility, medical structure configuration | Health insurance and forms of participation, medical quality structure | Qualitative investigation |

(continued)

**Table 1.** Continued.

| Author | Year | Territory | Latent variable | Independent variable | Formal evaluation |
|---|---|---|---|---|---|
| Liang Yong, etc.[41] | 2015 | | Medical structure configuration | Medical quality structure, medical manpower structure, medical material resource structure | Qualitative investigation |
| Barber, etc.[42] | 2017 | | Welfare healthcare, medical service accessibility | Coverage of medical services, health indicator, medical quality structure, medical insurance, and participation mode | Qualitative investigation |
| Rotter, etc.[43] | 2010 | | Welfare healthcare, clinical pathway management | ALO, construction rate of sustainable health management mechanism, medical insurance, and participation mode | Quantitative study |

Medical structure configuration involves planning and organizing human resources, material assets, and service quality within the healthcare system. It includes staffing, training healthcare professionals, managing medical equipment and medications, and ensuring service standards and quality.[33] Expanding medical structure configuration, improving nursing quality and efficiency, and addressing service imbalances and patient flow are the current focal points in advancing medical reforms.[41,46] The China Central Television network points out that there is a mismatch between patient demands and healthcare service provisions, necessitating the establishment of a closely connected county-level medical network to facilitate mutual exchange of patient referral information. Through the construction of county-level medical communities, the healthcare service system at the county, township, and village levels can be improved. Within the context of welfare, healthcare systems, equality, and justice are fundamental principles, and the rationality of medical structure configuration directly influences the construction of welfare healthcare.

Medical service accessibility means geographical factors that influence the ability to access health services, including the location and number of healthcare providers and the distances and transportation networks between them and the local population.[46] Research findings have unveiled specific healthcare service accessibility-related indicators of local spaces accessing primary-level healthcare services.[35] The HRSA updates data related to health center service delivery (HCSD) sites, health professional shortage areas (HPSAs), and medically underserved areas/populations (MUA/P) on a daily basis, reflecting that the population coverage and quantity of medical services are linked to the SWB of the population. It should be noted that nearly all primary care SA studies to date, whether based on simple or complex measures, have been limited to the exploration of social inequity in access, or the impact of SA on healthcare utilization. The body of work will be greatly advanced when we begin to precisely quantify how the SA of primary care actually impacts population health.[47]

The 1993 World Summit on Medical Education proposed the establishment of a bidirectional referral system between community health service agencies and hospitals as an essential component of an efficient healthcare service system. In 1997, China first proposed in the "Decision on Medical Reform and Development by the CPC Central Committee and the State Council"[48] to "incorporate community medical services into employee medical insurance and establish a two-way referral system." Over the past 25 years, the construction of the two-way referral system has gone through different stages. During this period, the country successively addressed the issue in policy documents such as the 2000 "Guiding Opinions on Urban Medical and Health System Reform,"[49] the 2006 "State Council's Guiding Opinions on Developing Urban Community Health Services,"[50] the 2015 "State Council's Guiding Opinions on Promoting the Construction of a Graded Medical System,"[51] and the 2023 "Measures for Convenient Services at the Grassroots Health and Family Planning Institutions,'[52] all of which repeatedly mentioned and emphasized the vigorous development of two-way referrals. These policy documents provide the basis and support for the construction of the two-way referral system. Research has demonstrated that electronic referrals (e-Referral) can bring substantial benefits to inter-organizational processes and patient care management[39] Nevertheless, fragmented care in two-way referrals can result in user dissatisfaction, poorer patient

outcomes, decreased service efficiency, and resource wastage, impeding the progress of welfare healthcare. It is imperative to establish seamless data sharing among institutions at various levels, aligning with their respective roles.[14]

The hypothesis model of this study is shown in Figure 1, and the research hypotheses are as follows:

***H1*:** Clinical pathway management is positively correlated with the welfare healthcare service system.
***H2*:** Medical structure configuration is positively associated with the welfare healthcare service system.
***H3*:** Medical service accessibility is positively correlated with the welfare healthcare service system.
***H4*:** Two-way referral bears a positive relation with the welfare healthcare service system.
***H5*:** Two-way referral shows a positive mediating effect on the relationship among clinical pathway management, medical structure configuration, medical service accessibility, and the welfare healthcare service system.

## Research method

### Research setting

This study was a cross-sectional study conducted at Wuhan Jinyintan Hospital from March to June 2023, involving patients with referral experience. The participants in the study included males and females aged between 18 and 60, with a total of 365 individuals participating in the survey. The study obtained ethical approval and obtained consent from the participants. The conceptual framework was based on the proposed hypotheses. The primary focus of this research was to examine the mediating impact of the latent variable two-way referral on the welfare healthcare system.

### Sampling technique

This study selected three representative hospitals in the Central China region as survey targets. Among them, samples from Wuhan Jinyintan Hospital accounted for 79%, samples from Union Hospital accounted for 6%, and samples from Tongji Hospital accounted for 5%. A total of 23 departments were involved, utilized a stratified random sampling approach. It was divided into four categories based on departments or specialized fields: Infectious Disease Department ($N = 109$), Intensive Care Unit ($N = 96$), Surgical Departments ($N = 71$), and Other Specialized Departments ($N = 89$).

Due to limitations in space and focus, we primarily reported the specific survey results conducted at Wuhan Jinyintan Hospital in the entire paper. This choice was made to delve deeper into the specific context of a particular hospital while ensuring the representativeness of the study.

### Data collections

We recruited 1–5 investigators in each department. And each investigator was required to distribute and recover 40–70 online questionnaires on a one-to-one basis. Before the investigation, investigators received standardized training about the content and precautions of the questionnaire to

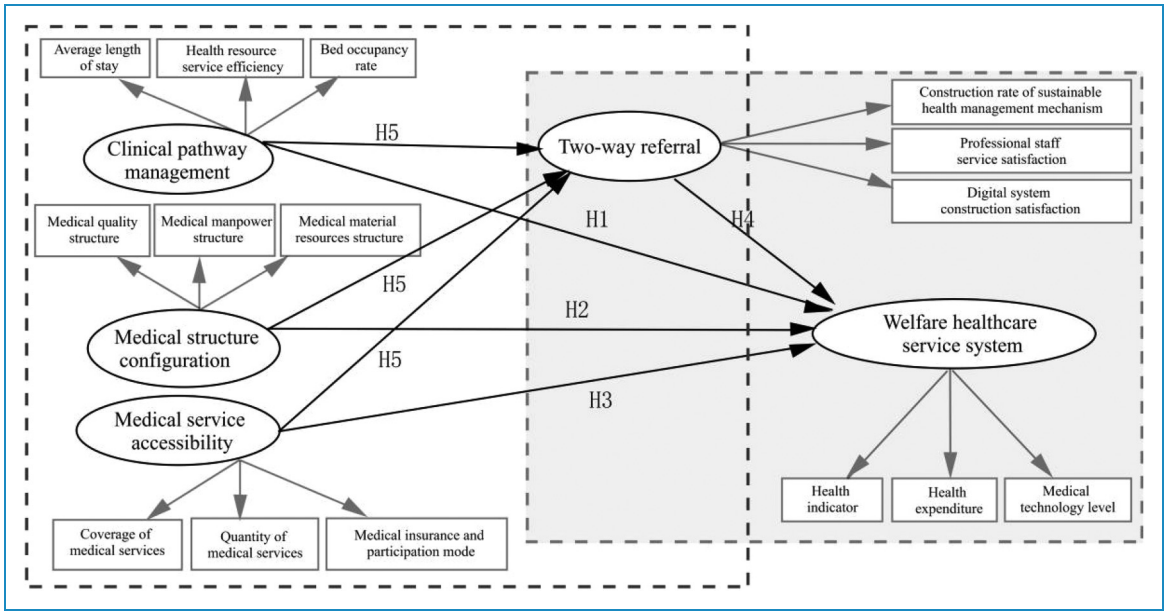


**Figure 1.** Welfare medical and health service system theory verification model. *Test the impact of integrated medical indicators on welfare care; integrated medical indicators include clinical pathway management, medical structure configuration, and medical service accessibility. The mediation effect of the two-way referral was also examined.

ensure the rigor of the questionnaire distribution process. A total of 365 questionnaires were collected. Questionnaires with logical inconsistencies ($N = 13$) and missing data ($N = 17$) were excluded. Finally, 335 valid questionnaires were obtained with an effective rate of 91.6%.

AMOS modeling requires at least 10 times the number of items,[53] and this study has 27 items. Therefore, a minimum of 270 data points is needed for AMOS modeling. A previous study[54] found that when using partial least squares structural equation modeling (PLS-SEM) for analysis, a minimum of 15 participants is required for each measured variable. However, considering the trade-off between survey cost and research accuracy, 365 questionnaires were distributed.

## Measures and variables

In the early stages of the study, SWB medical health assessment questionnaires were originally designed through literature searches and group discussions. Each variable part of this study corresponds to a scale, which is respectively Service Quality Scale (Servqual), Caregiver Reaction Assessment (CRA) scale, Primary Care Assessment Tool (PCAT) scale, Nurse–Physician Collaboration Scale (NPCS), and Perceived Involvement in Care Scale (PICS). All measures are shown in Supplementary Table 1.

To measure clinical quality (CQ1–CQ3), we utilized the Servqual. Based on the service quality theory,[55] reliability, responsiveness, and empathy are directly related to the core objectives pursued by clinical pathway management. Care tailored to individual patient needs aims to achieve standardization and more efficient nursing, leading to shortened hospital stays, rapid admission processes, and moderate bed occupancy rates. These factors significantly impact the stability of treatment plans and service efficiency.[56,57]To evaluate patients' attitudes toward welfare healthcare (WH1–WH3), we adopted the CRA scale.[58]Good health validates the effectiveness of the healthcare service system. Many studies on caregiving have examined the impact of changes in emotional responses during care on healthcare.[53] Montgomery pointed out the need for a more detailed examination of the burden measures and descriptions of different types of burdens.[54]Therefore, physical health, perceived burden, and personal growth in the CRA are chosen as core dimensions and incorporated into the assessment of the Well-being Healthcare Service System. Furthermore, the NPCS[59] was taken to measure healthcare service accessibility (MSA1–MSA3).The dimensions of the NPCS are conducive to assessing healthcare collaboration, such as caring and respecting different populations (mutual respect) and promoting clear responsibilities and collaboration among diverse healthcare teams to ensure coverage for a broader audience (shared decision-making). Through effective communication (open communication), enhancing insured individuals' understanding of various insurance methods contributes to improving healthcare accessibility.[38,40,42]The PCAT[60] was introduced to examine medical structure configuration (MSC1–MSC2), evaluating medical team collaboration ability and judging the rationality of medical structures. Based on the dimensions set by the PCAT, the assessment includes aspects such as the initial contact process, care continuity, comprehensiveness, and coordination. This showcases the overall performance of healthcare institutions in delivering primary healthcare services.[40] The goal is to ensure that patients receive high-quality, continuous, comprehensive, and coordinated primary care services. In order to gauge bidirectional referrals (TR1–TR3), the PICS[61] was employed to evaluate the medical involvement perceived by patients. The PICS comprises three dimensions: information gathering, treatment collaboration, and decision sharing. The extent to which patients acquire information during the medical process reflects the sustainability of the healthcare management mechanism. The quality of service provided by healthcare professionals during the treatment process is directly tied to the satisfaction of healthcare professionals. The satisfaction with digital system development can assess the extent to which patients and healthcare professionals jointly participate in medical decision-making.[62]

To confirm the internal reliability of the variables contained in our scales, we conducted a scale reliability analysis .As can be seen from Table 2, Cronbach's alpha coefficient of each variable is greater than 0.8. Generally, it is believed that if Cronbach's alpha coefficient of the variable is greater than 0.7, the data reliability is qualified. All Cronbach's values demonstrated good to excellent reliability (all >0.70, range = 0.77–0.86).

## Statistical methods

In this study, exploratory analysis used SPSS 26 and confirmatory factor analysis and SEM analysis used AMOS 24. Statistical significance was set at $P < 0.05$. First, we obtained statistics on frequency ($N$) and percentage (%) to show the characteristics of the referred patients. Second, we obtained the mean ($M$) and standard deviation ($SD$) statistics to show the scores of integrated care indicators and two-way referrals in each dimension. Finally, the PLS-SEM is also used as a statistical procedure that allows testing of non-straightforward relationships and is therefore well suited to the management of cross-sectional data for inferential purposes.[63] The SEM was used to verify the injection path of various factors on the SWB healthcare. The maximum likelihood estimation was performed in the SEM. (Note: The scores of integrated medical indicators and two-way referrals were in line with normal distribution in all dimensions.)

The purpose of this research was to systematically examine the impact of healthcare quality management indicators on the construction of the welfare healthcare service

**Table 2.** Descriptive statistics of model latent variables and reliability testing of scales ($N = 335$).

| | M | SD | Range | | Variable indicators | Cronbach's alpha |
|---|---|---|---|---|---|---|
| Servqual | 4.552 | 0.951 | Clinical pathway management | CQ1 | Average length of stay | 0.857 |
| | | | | CQ2 | Health resource service efficiency | |
| | | | | CQ3 | Bed occupancy rate | |
| PCAT scale | 4.667 | 1.247 | Medical structure configuration | MSC1 | Medical quality structure | 0.892 |
| | | | | MSC2 | Medical manpower structure | |
| | | | | MSC3 | Medical material resource structure | |
| NPCS | 4.392 | 0.861 | Medical service accessibility | MSA1 | Coverage of medical services | 0.838 |
| | | | | MSA2 | Quantity of medical services | |
| | | | | MSA3 | Medical insurance and participation mode | |
| PICS Scale | 3.947 | 1.359 | Two-way referral | TR1 | Construction rate of sustainable health management mechanism | 0.805 |
| | | | | TR2 | Professional staff service satisfaction | |
| | | | | TR3 | Digital system construction satisfaction | |
| CRA scale | 4.505 | 1.332 | Welfare healthcare | WH1 | Health indicator | 0.864 |
| | | | | WH2 | Health expenditure | |
| | | | | WH3 | Medical technology level | |

system. This analysis was limited to participants ($N = 335$) with complete data on the latent outcome variables of interest, i.e., factors influencing the welfare healthcare system. Considering the moderate sample size, we employed a non-parametric bootstrapping procedure with 350 iterations for resampling to increase our confidence in statistical interpretation and inference. In the final model, standardized control was made on gender, age, education level, and income. To ascertain the overall fitting degree of the model, we harnessed SEM's standard cutoff point to test data quality.

## Result

### *Finally adjusted SEM fitting*

The value of CMIN/DF of the measurement model is 1.593, in the middle of 1–3; the value of RMSEA is 0.043, and the model is less than 0.08 (GFI = 0.951, AFGI = 0.926, CFI = 0.982); the values are greater than 0.9. It follows that the measurement model fit is ideal.

Under the premise that the scale CFA model has good fit, the convergent validity (AVE) and combined reliability (CR) of the scale dimensions are further tested. The test process calculates the standardized factor load of each measurement item in the corresponding dimension through the established CFA model. The minimum requirement for average variance extracted (AVE) value of 0.5 and the minimum CR value of 0.7 can indicate good convergent validity and combined reliability. The calculation results are shown in Table 3.

The standardized correlation coefficients between each pair of dimensions are all smaller than the square root of the corresponding AVE values for each dimension. This indicates that there is good discriminant validity among the various dimensions in the preliminary theoretical model. The results are shown in Table 4.

As can be seen from the above table, there is a significant correlation between each variable, and the absolute value of the correlation coefficient between each variable is less than the corresponding AVE square root, indicating that each variable has a certain correlation and a certain degree of differentiation. Therefore, the study data had good discriminatory validity.

The results of the model test show that $X^2$ (80) = 127.477, in the range of 1–3, RMSEA (RMSE) = 0.043, CFI = 0.982, TLI = 0.976, and IFI = 0.982.Therefore, the

**Table 3.** Convergent validity and CR test of each element in the welfare healthcare service system.

| Path relationship | | | Estimate | AVE | CR |
|---|---|---|---|---|---|
| GA3 | ← | GA | 0.822 | 0.672 | 0.860 |
| GA2 | ← | GA | 0.866 | | |
| GA1 | ← | GA | 0.77 | | |
| GB3 | ← | GB | 0.901 | 0.744 | 0.897 |
| GB2 | ← | GB | 0.917 | | |
| GB1 | ← | GB | 0.761 | | |
| GC3 | ← | GC | 0.901 | 0.664 | 0.856 |
| GC2 | ← | GC | 0.743 | | |
| GC1 | ← | GC | 0.797 | | |
| GD3 | ← | GD | 0.805 | 0.581 | 0.806 |
| GD2 | ← | GD | 0.706 | | |
| GD1 | ← | GD | 0.772 | | |
| GE3 | ← | GE | 0.847 | 0.690 | 0.869 |
| GE2 | ← | GE | 0.901 | | |
| GE1 | ← | GE | 0.735 | | |

**Table 4.** Discriminant validity test.

| | GA | GB | GC | GD | GD |
|---|---|---|---|---|---|
| GA | 0.82 | | | | |
| GB | 0.307*** | 0.862 | | | |
| GC | 0.284*** | 0.502*** | 0.815 | | |
| GD | 0.299*** | 0.429*** | 0.346*** | 0.762 | |
| GE | 0.324*** | 0.436*** | 0.365*** | 0.374*** | 0.831 |

***Represents $p < 0.001$; the diagonal is the AVE square root.

results of this analysis show that the SEM model has a good fit. The path relationships of the models are shown in Table 5.

Bidirectional referral was positively correlated with clinical pathway management, medical structure configuration, medical service accessibility, and the welfare healthcare service system. As exhibited in Table 3, two-way referral was evidently associated with clinical pathway management (A: $\beta = 0.16$, $p = 0.013$), medical structure configuration (B: $\beta = 0.31$, $p < 0.001$), medical service accessibility (C: $\beta = 0.15$, $p = 0.046$), and the welfare healthcare service system (G: $\beta = 0.18$, $p = 0.012$).

Regarding the influencing factors of the welfare medical system, the system presented a significant correlation with clinical pathway management (D: $\beta = 0.16$, $p = 0.012$), medical structure configuration (E: $\beta = 0.02$, $p < 0.001$), and medical service accessibility (F: $\beta = 0.14$, $p = 0.045$).

## *Testing for direct and indirect (mediating) effects*

Partial mediation was observed in the mediation test for Hypothesis 5, as detailed in Table 6. In this study, the Bootstrap mediation effect testing procedure was used to test the mediation effect.[64] The outcomes of the mediation analysis are as follows: Path A → G represented that clinical pathway management, which included the mediating variable two-way referral, exerted an impact on the welfare healthcare service system. Two-way referral partially modulated the correlation between clinical pathway management and the welfare healthcare service system. After incorporating two-way referral into the model, the direct influence of clinical pathway management on the welfare healthcare service system remained significant [D (pre-mediation): $\beta = 0.158$, $p < 0.05$; D (post-mediation): $\beta = 0.187$, $p < 0.05$).] The decreasing $p$-value of the direct effect suggested that two-way referral acted positively as a mediating variable on clinical pathway management and welfare healthcare. The indirect positive influence of clinical pathway management on the welfare healthcare service system (A–G: $\beta = 0.234$, $p < 0.05$), as well as the direct influence of two-way referral on the welfare healthcare service system (G: $\beta = 0.175$, $p < 0.05$), remained statistically significant, providing further support for partial mediation.

Two-way referral partially regulated the association between medical structure configuration and the welfare healthcare service system. Path B → G reflected that medical structure configuration, which encompassed the mediating variable two-way referral, acted on the welfare healthcare service system. After introducing two-way referral into the model, the direct effect of medical structure configuration on the welfare healthcare service system stayed evident [E (pre-mediation): $\beta = 0.244$, $p < 0.001$; E (post-mediation): $\beta = 0.299$, $p < 0.001$]. The indirect positive effect of medical structure configuration on the welfare healthcare service system (B–G: $\beta = 0.043$, $p < 0.05$), as well as the direct effect of two-way referral on welfare healthcare (B–G: $\beta = 0.198$, $p < 0.05$), remained statistically meaningful, confirming the function of partial mediation.

Two-way referral partially modulated the correlation between medical service accessibility and the welfare healthcare service system. Path C → G denoted that

**Table 5.** Results of the pathway relationship hypothesis testing of the SEM model.

| Number | Path relationship | | | Estimate | S.E. | C.R. | P |
|---|---|---|---|---|---|---|---|
| A | Two-way referral | ← | Clinical pathway management | 0.163 | 0.617 | 2.474 | 0.013 |
| B | Two-way referral | ← | Medical structure configuration | 0.305 | 0.068 | 4.105 | *** |
| C | Two-way referral | ← | Medical service accessibility | 0.147 | 0.088 | 1.994 | 0.046 |
| D | Welfare healthcare | ← | Clinical pathway management | 0.158 | 0.513 | 2.519 | 0.012 |
| E | Welfare healthcare | ← | Medical structure configuration | 0.244 | 0.058 | 3.391 | *** |
| F | Welfare healthcare | ← | Medical service accessibility | 0.137 | 0.072 | 2.002 | 0.045 |
| G | Welfare healthcare | ← | Two-way referral | 0.175 | 0.061 | 2.506 | 0.012 |

**Table 6.** Results of the bootstrap method for testing mediation effects.

| Path relationship | Parameter | Estimate | Lower | Upper | P | Proportion of the effect | Intermediate effect result |
|---|---|---|---|---|---|---|---|
| A → G | Indirect effect | 0.234 | 0.024 | 0.731 | 0.023 | 15% | Partial mediation |
| | Direct effect | 1.292 | 0.194 | 2.519 | 0.020 | 85% | |
| | Total effect | 1.525 | 0.383 | 2.709 | 0.008 | – | |
| B → G | Indirect effect | 0.043 | 0.009 | 0.094 | 0.020 | 18% | Partial mediation |
| | Direct effect | 0.198 | 0.062 | 0.343 | 0.005 | 82% | |
| | Total effect | 0.241 | 0.106 | 0.374 | 0.003 | – | |
| C → G | Indirect effect | 0.027 | 0.001 | 0.081 | 0.042 | 16% | Partial mediation |
| | Direct effect | 0.144 | 0.017 | 0.314 | 0.021 | 84% | |
| | Total effect | 0.171 | 0.03 | 0.341 | 0.009 | – | |

medical structure configuration, which included the mediating variable two-way referral, exerted an impact on the welfare healthcare service system. Subsequent to the incorporation of two-way referral into the model, the direct effect of medical service accessibility on the welfare healthcare service system continued to be significant [(F (pre-mediation): $\beta = 0.137$, $p < 0.05$; F (post-mediation): $\beta = 0.162$, $p < 0.05$)]. The decreasing $p$-value of the direct effect demonstrated the positive mediating role of two-way referral. The indirect positive impact of medical service accessibility on the welfare healthcare service system (C–G: $\beta = 0.027$, $p < 0.05$), as well as the direct effect of two-way referral on welfare healthcare (C–G: $\beta = 0.144$, $p < 0.05$), remained statistically meaningful, offering further support for partial mediation.

## *Overall effects*

Overall, all variables affecting the welfare healthcare service system were positively correlated and statistically significant. Smaller $p$-values denoted stronger support for the hypotheses. Based on the hypothesis testing results, the sufficiency of the parameters was ranked as follows: medical service accessibility < clinical pathway management < two-way referral < medical structure configuration. The $p$-values of each pathway are significant, verifying the hypothesis that H1–H5 holds, and the calculated results based on the SEM are shown in Figure 2.

The outcomes indicated that two-way referral partially mediated the integrated medical indices. Prior to the inclusion of two-way referral, the results were essentially the same in all three scenarios (direct effect: $p < 0.05$, indirect effect < 0.050).

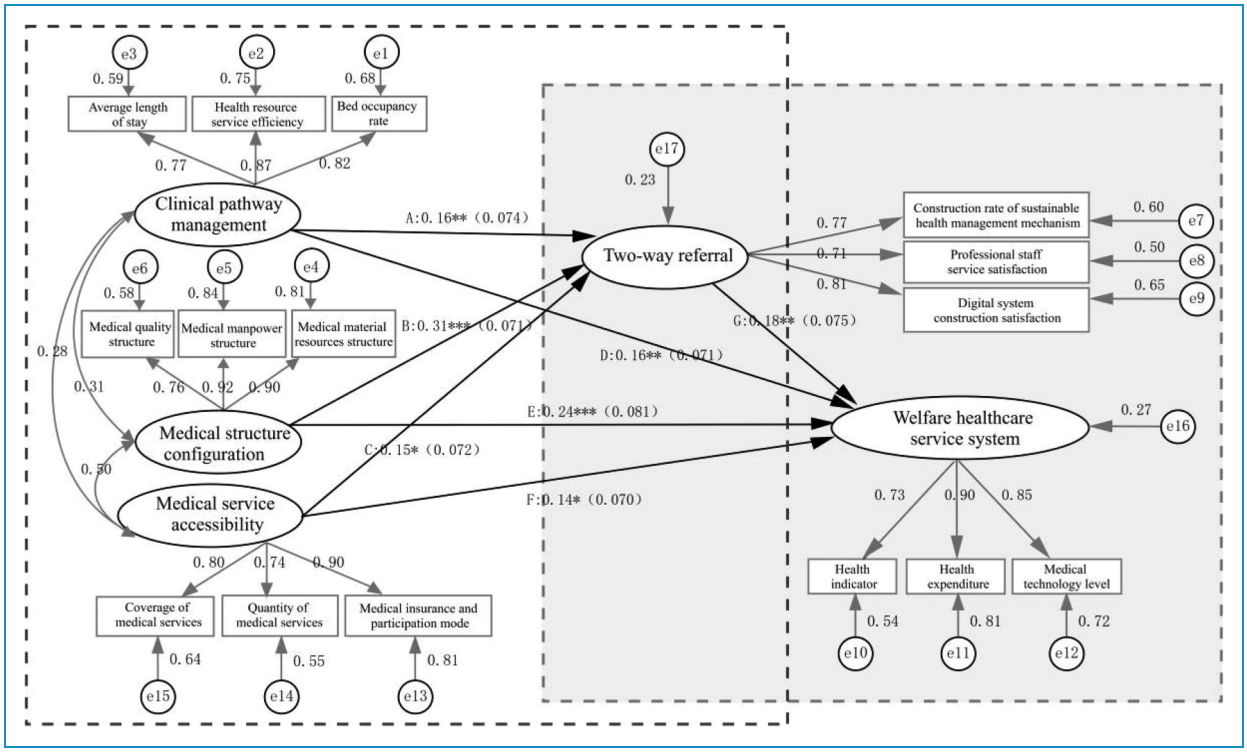


**Figure 2.** Outcomes of model fitting. *After testing the association between integrated care and well-being care with a two-way referral as the mediating variable, a structural model with standardized regression weights was finally shown. The results of the model test show that $X^2$ (80) = 127.477, in the range of 1–3, RMSEA (RMSE) = 0.043, CFI = 0.982, TLI = 0.976, and IFI = 0.982. The results of this analysis show that the SEM model has a good fit. *** Represents $p < 0.001$, * * $p < 0.01$, and * $p < 0.05$. Partial mediation effects were observed in the mediation test, and the influence of integrated medical indicators on welfare care mainly occurred through direct influence, and two-way referral played a complementary role.

The effect proportions were between 80% < direct effect < 85% and 15% < indirect effect < 20%. Although the indirect effect was relatively small, there was a clear mediating mechanism, and the impact of integrated medical care on welfare healthcare mainly occurred through direct effects, with two-way referrals exerting a complementary function. In all three scenarios, the impact of the integrated indicators on welfare healthcare was very similar, hinting a strong correlation between clinical pathways, medical structures, and medical accessibility with the construction of welfare-oriented healthcare. As components of the medical supply system, alterations in these three aspects directly could affect the quality of the medical system. This validated the important role of these three factors in promoting the development of welfare healthcare and suggested that they should be prioritized. The existence of direct effects also reflected the closeness of the relationships among them, and improvements in each of them would have a boosting influence on welfare healthcare.

## Discussion

### *Summary of survey results*

Our research findings provided evidence for the proposed hypotheses, demonstrating the positive impact of integrated medical indicators on welfare healthcare. Through the mediating role of bidirectional referral, the significance of two-way referrals in bridging primary-level healthcare with health data science is emphasized.

Firstly, medical structure configuration exerted a positive impact on the construction of the welfare healthcare system. Among the three latent variables, medical structure configuration stood as the most significant influencing factor on welfare healthcare and was directly related to it. It suggested that achieving a synergistic governance structure involving diverse stakeholders requires a restructuring and reconfiguration of the relationships among the government, the society, and the market, overcoming governance challenges such as the inadequacy of the tiered diagnosis and treatment system, regulatory deficiencies, and imbalances in the workforce, thus ensuring the development and sustainability of the synergistic governance system.[33]

Clinical pathway management standardizes healthcare services by defining diagnostic and treatment protocols, and it is supported by various studies. For example, in the United States, diagnosis-related groups (DRGs) provide strict guidelines for different diseases,[65] while in Australia, data standardization aids in summarizing and categorizing information for standardized clinical pathways.[66]

It is recommended to develop hospital-specific clinical pathways based on clinical evidence and expert experience. These pathways should be applied in clinical practice using information technology, and mechanisms for assessment, rewards, penalties, supervision, and feedback should be established. This approach can eliminate unnecessary medical steps, improve medical efficiency, and control excessive growth in healthcare costs.

As shown by the results of our investigation, improving healthcare service accessibility exerted a positive impact on welfare healthcare. Our study revealed that more proactive healthcare insurance and enrollment methods had a greater influence on healthcare service accessibility. The wide coverage and fairness of health insurance are crucial. Implementing a capitation-based family doctor contracting system and guiding tiered diagnosis and treatment, while also enhancing primary-level service capacity, ensure fair access to healthcare. Strengthening healthcare information systems and expanding medical insurance coverage provide convenience for patients.[67,68]

Our investigation emphasized the partial mediating role of bidirectional referrals. Satisfaction with digital system development and the continuous health management mechanism directly influence referral outcomes. This finding reaffirms that electronic referrals can offer a superior and more effective experience compared to traditional referrals.[69] Referrals bridge integrated healthcare indicators with welfare healthcare, providing insights into basic services. It is recommended to establish a unified regional health information platform and enhance satisfaction with digital system development. Empowering patients with autonomy in health management promotes a patient-centered "Internet + healthcare" model. Developing patient health management applications is essential to enable holistic health tracking throughout the entire life cycle and transition healthcare management from treatment-focused to prevention-focused.

### *Existing problems and path mechanism design*

Research shows that the patient acceptance rate for bidirectional referrals is only 36.2%.[70] Data also indicates that the rate of continuous health management mechanism construction and satisfaction with digital system development is only 24.8%. According to Kahneman and Tversky's prospect theory, people are more sensitive to losses than gains, a phenomenon known as loss aversion. The low acceptance of the referral system may be due to patients' sensitivity to potential health losses and their lack of trust in the technical capabilities of basic-level medical institutions. Additionally, patients' choices and referral experiences are influenced by factors such as lack of information about referral benefits, uncertainty about receiving hospitals, and complex referral processes (as shown in Figure 3). Mechanisms need to be designed to change patients' healthcare-seeking intentions and increase their acceptance of bidirectional referrals. In order to enable patients to clearly see the specific improvements in primary healthcare quality and the benefits of referral, a transparent referral benefit feedback model should be established to increase patients' acceptance of referrals. In Australia, 88.9% of primary healthcare institutions have participated in the physical activity referral scheme (PARS), complemented by a comprehensive referral information platform.[71] The referral information platform, coordinated across seven major modules, provides suitability screening, convenient access, clear process tracking, and other relevant aspects for physical activity referrals (such as obtaining referral personnel information and informed consent, monitoring referral process and outcomes, assessment, and feedback), vigorously enhancing the certainty effect of participating entities and mitigating patients' existing biases. Therefore, the referral benefit feedback model should consist of the following seven major modules (see Figure 4).

### *Implementation of the welfare healthcare system referral service model*

As shown in Table 7, patients initially register on the health management platform, where an AI guide collects basic information, medical history, and symptoms. Based on this, patients are directed to a local hospital (LH). If the LH can provide treatment, patients continue there. If a referral is needed, the LH physician submits a request to the referral hospital (RH) through the platform. Patients receive referral benefit feedback to understand the process and medical team. At RH, the responsible physician diagnoses and treats the patient, with AI monitoring data entry. During rehabilitation, the medical team monitors progress, adjusts plans, and communicates with patients through the platform. After completing rehabilitation, patients provide feedback via questionnaires to improve services. Patients can also address equipment needs or community communication through the platform. Later, they can make appointments for assessments at community health centers, where referrals are determined as necessary. This dynamic management involves community centers, hospitals, and specialized institutions effectively, with information integrated and shared across levels for comprehensive chronic disease management.

## Conclusions

The continuous healthcare management mechanism plays a significant part in improving the accessibility and convenience of high-quality medical resources. Simultaneously, it greatly contributes to optimizing the configuration of medical structures, increasing patient acceptance of

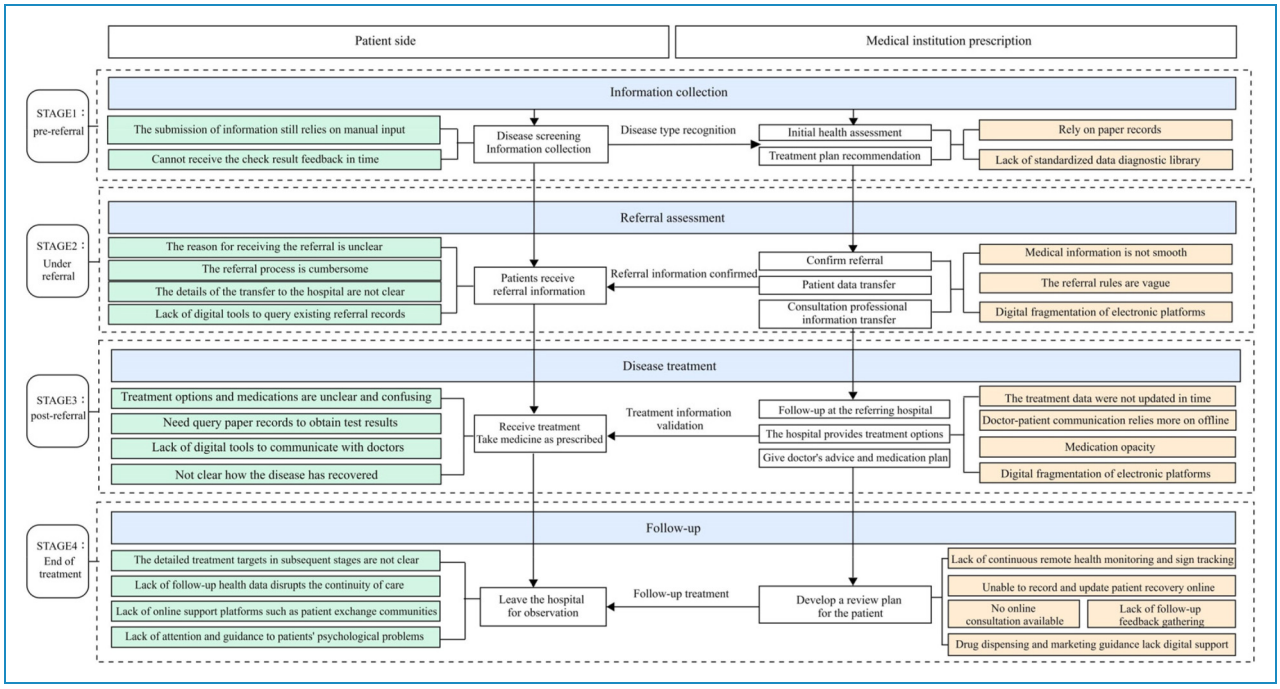


**Figure 3.** Visualized referral information path analysis. *The information was obtained through on-site research at Wuhan Jinyintan Hospital. Practical problems from the perspective of the patient side and the medical provider in the middle and late stages before referral and in the subsequent stages of the end of treatment.

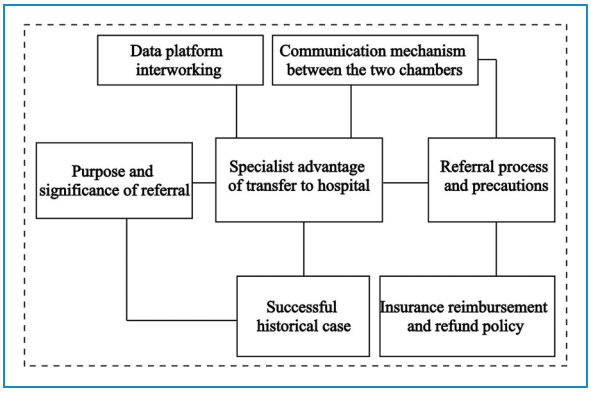


**Figure 4.** Referral Feedback Information Module. * Adapted from the Australian Physical Activity Referral 6E'e Evaluation Model.

bidirectional referrals, and reducing doctor–patient disputes. Utilizing digital platforms can streamline referral processes, improve efficiency, and facilitate timely interventions in remote healthcare. Big data platforms assist clinical decision-making and provide personalized rehabilitation plans. Similar to family doctors, physical therapists focus on home-based health management, emphasizing continuous monitoring to formulate long-term health management plans. Nevertheless, physical therapists differ in their integration of resources across various disciplines with online teamwork, using professional equipment and information systems to achieve more systematic and specific rehabilitation training programs. Moreover, they place greater emphasis on psychological support and social integration.

It is recommended that the patient-centered integrated medical and healthcare service system be guided by the needs of patients. On the one hand, there are significant challenges in public health due to issues such as aging, environmental pollution, and food safety. On the other hand, with the issuance of documents such as the "Outline for the "Healthy China 2030' Initiative" and the "14th Five-Year Plan for National Health," there are immense opportunities for the development of welfare healthcare. In policy documents such as the "Enhancement Plan for Birth Defect Prevention and Control (2023–2027)" released on August 17, 2023,[72] and the "Technical Evaluation Scheme for the Treatment System of Critically Ill Pregnant Women" issued on December 27, 2023,[73] there are repeated mentions of expediting the establishment and application of remote medical platforms. The emphasis is particularly placed on the assessment of referral data information and the importance of online referrals. This is expected to trigger more related research. Digital referral is not only a trend in future healthcare reform studies but also a focal point in the construction of the medical alliance system. Coordinating with a well-designed digital triage and referral mechanism is a crucial pillar for achieving high-quality, accessible, and efficient welfare healthcare.

**Table 7.** Welfare healthcare service blueprint.

| Stage | Initial diagnosis stage | | Referral to treatment phase | | Health follow-up stage | | | | Subsequent rehabilitation phase | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Step (from top to bottom) | Patient registration | AI guide | LH Referral | RH | Rehabilitation program | Rehabilitation care | Follow-up supervision of healthcare projects | Healthcare team evaluation system | Device consumption demand | Community communication | Regular check |
| Make an appointment | √ | | | | | | | | | | √ |
| Diagnostic suggestion | | | √ | √ | | √ | √ | √ | | | |
| Diagnostic results | | √ | √ | √ | | | | √ | | | |
| AI intelligent monitoring | | √ | | | √ | √ | √ | | | | |
| Patient information database | | √ | √ | √ | √ | | | √ | | | √ |
| Referral benefit feedback model | | | √ | | √ | | | | | | |
| Professional physician matching rehabilitation system | | √ | √ | √ | | √ | √ | | | | |
| Prescription and drug progress follow-up | | | | √ | | √ | √ | √ | | | |
| Rehabilitation indicators | | | | | √ | | √ | | | | |

(continued)

**Table 7.** Continued.

| Stage | Initial diagnosis stage | Referral to treatment phase | Health follow-up stage | | | | Subsequent rehabilitation phase | |
|---|---|---|---|---|---|---|---|---|
| Physical therapist follow-up | | | √ | √ | √ | | | |
| VR/AR hospital communication | √ | √ | | √ | √ | √ | √ | |
| Pre-diagnosis and early warning system | | | | | √ | | | |
| Pre-diagnosis and early warning system | | | √ | √ | √ | √ | | |
| Questionnaire feedback collection | | | | | | √ | | √ |
| Shopping/ community communication platform | | | | | | | | √ |

## Strengths and limitations of this study

This research calls for patient-centered care and a digital platform to improve referral services and acceptance within welfare healthcare. This study contains several notable limitations. Firstly, the majority of the samples are derived from patients at Wuhan Jinyintan Hospital. Future research endeavors should focus on broadening the sample coverage, considering the inclusion of more representative hospitals, to ensure a more comprehensive understanding of the situation in Central China. Due to the sources of sample collection from official data and questionnaire surveys, and a specific focus on the healthcare market in Central China, the results of this study may not be applicable to, nor representative of, the global healthcare situation, especially in remote areas or special medical institutions. Future research should emphasize comparisons with healthcare systems in other countries and formulate evaluation models for the influencing factors of digital health platforms. Secondly, future research should pay greater attention to the application of advanced technologies (such as 5G, IoT, and ML) in the field of medicine. Additionally, digital platforms pose risks related to network security, including data breaches, as well as risks associated with the disclosure of patient privacy. Legal and ethical concerns need to be addressed. The construction of digital medical platforms requires substantial investment in system development, equipment procurement, network infrastructure, etc. This necessitates strong support from both the government and social capital, along with continuous efforts to reduce construction and operational costs.

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