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Study on the Application Value of Teleradiology in Primary-Level Imaging Services Under the Medical Alliance Model

Chungeng Tang[1], Xingxiong Zou[1], Jie Zhang[1], Menghong Zou[1], Ruohan Feng[1], Tao Li[2], Kang Zhou[3], Hui Li[3], Chunlei Jia[3], Hongwei Li[1*]

[1]Department of Radiology, The Third Hospital of Mianyang, Sichuan Mental Health Center, Mianyang 621000, Sichuan, China

[2]Department of Radiology, Mianyang Youxian District People's Hospital, Mianyang 621000, Sichuan, China

[3]Internet Hospital, The Third Hospital of Mianyang, Sichuan Mental Health Center, Mianyang 621000, Sichuan, China

***Corresponding author*:** Hongwei Li, lhw6321@163.com

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Abstract: *Background*: Primary health care (PHC) is a fundamental component of achieving universal health coverage (UHC). However, in many resource-limited settings, primary health care institutions still face problems such as underutilization of medical imaging equipment, a shortage of professional imaging personnel, and insufficient patient recognition of the diagnostic and therapeutic capacity of primary care. As a result, there is a clear mismatch between the diagnostic service capacity of primary care and residents' medical needs. The uneven allocation of imaging resources further limits the functioning of the primary health system. Therefore, it is of great significance to explore sustainable models that rely on digital technology to enhance primary-level imaging service capacity, optimize the allocation of medical resources, and strengthen trust in primary care. *Methods*: This study conducted a cross-sectional empirical study based on a multi-stakeholder survey in southwestern China from January 2025 to January 2026. The study covered 59 primary health care institutions and obtained 118 valid questionnaires, including primary health care institution administrators (n=55) and primary care clinicians (n=63). Imaging quality control indicators were also incorporated for comprehensive evaluation. Guided by health service supply-demand theory and medical trust theory, the study constructed an analytical framework of "improving service supply—enhancing diagnostic and therapeutic quality—reshaping trust relationships" to systematically evaluate the impact of teleradiology implementation on primary-level imaging service capacity and medical quality. *Results*: The survey showed that the shortage of imaging professionals in primary health care institutions was prominent. Among primary health care institution administrators, 85.5% (47/55) reported a shortage of radiology professionals. Primary care physicians were highly dependent on imaging examinations to assist diagnosis and treatment. The proportion of imaging examination needs for common diseases reached 84.1%–98.4% (acute abdomen 93.7%, pneumonia and pneumothorax 96.8%, fracture 98.4%, stroke 98.4%, myocardial infarction 84.1%). However, only 4.8% (3/63) of primary care physicians believed that primary care institutions had strong independent imaging diagnostic capacity. After the application of teleradiology, the imaging

diagnostic concordance rate increased from 58.3% to 91.7%, and the missed diagnosis rate decreased from 12.4% to 2.1%. In addition, 96.4% (53/55) of primary care administrators reported that teleradiology promoted an increase in the number of patient visits, and 92.9% (59/63) of primary care physicians recognized the quality of remote imaging reports. *Conclusion*: Teleradiology helps alleviate the shortage of primary-level imaging resources and promotes the improvement of primary-level imaging service capacity by enhancing diagnostic support capacity, optimizing service supply, and strengthening medical trust. Based on empirical data from southwestern China, this study provides a reference for digital technology empowering the development of the primary health system and optimizing the allocation of imaging resources.

Keywords: Teleradiology; Primary care; Health system; Medical trust; Health equity; Universal health coverage

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1. Introduction

Primary health care (PHC) is an important foundation for achieving universal health coverage (UHC), but primary health care systems have long faced challenges such as a shortage of professionals, limited service capacity, and insufficient trust among residents [1-3]. China's primary health care also has an obvious imbalance between supply and demand. With population aging and the increasing burden of chronic diseases, the demand for primary health care services continues to grow, while the allocation of high-level professional and technical personnel is insufficient. In 2024, only 39.9% of practicing (assistant) physicians in township health centers had a bachelor's degree or above, lower than the 64.0% in urban community health service centers [4]. At the same time, medical imaging data are growing rapidly, while the growth rate of radiology professionals has lagged relatively behind, making the insufficient imaging diagnostic capacity at the primary level increasingly prominent [5,6]. Although China has continued to promote primary-level talent training and policies to channel medical resources to the primary level in recent years, the insufficient supply of high-level imaging services at the primary level has not been fundamentally improved.

Medical imaging is an important support for disease screening, diagnosis, and treatment decisions, and is also an important component of achieving universal health coverage. In 2025, the 78th World Health Assembly adopted resolution WHA78.13, incorporating medical imaging services into areas related to universal health coverage. Studies have shown that low- and middle-income countries generally face insufficient imaging equipment, professionals, and service accessibility, which limits the improvement of disease diagnosis and treatment capacity at the primary level [7-8]. For primary health care institutions, the quality of imaging reports not only affects clinical decisions but also affects patients' recognition of primary health care services.

From the perspective of health service supply-demand theory, medical imaging services are highly professionally dependent and resource-constrained, and primary-level areas are prone to forming a structural contradiction of "increased medical demand—insufficient professional supply." International studies have found that India, Germany, Australia, and other countries all have problems with uneven urban-rural distribution of radiologists, and insufficient spatial allocation of imaging resources has become a common challenge for the development of primary health systems [9-11]. At the same time, medical trust theory holds that the trust of patients and medical personnel in medical service capacity is an important factor affecting the utilization of medical resources. Insufficient primary-level imaging diagnostic capacity may reduce the

trust of primary care physicians and patients in primary health care services, further concentrating medical demand in higher-level hospitals and exacerbating regional imbalances in medical resources [12-13].

Teleradiology, relying on digital image transmission and remote diagnostic technology, provides a new service model for alleviating the shortage of primary-level imaging resources. Previous studies have shown that teleradiology can improve the accessibility of imaging services, improve diagnostic efficiency, and promote the extension of high-quality imaging resources to the primary level [10,14-16]. However, current related research mainly focuses on remote diagnostic accuracy and technical application effects, and research on how it improves the supply-demand relationship of primary-level imaging services and promotes the construction of medical trust is still relatively insufficient.

Therefore, based on health service supply-demand theory and medical trust theory, and relying on survey data from 59 primary health care institutions in southwestern China, this study systematically analyzes the current application status of teleradiology in primary care and its impact on imaging service capacity, diagnostic and therapeutic quality, and trust relationships, providing empirical evidence for optimizing the allocation of primary-level imaging resources and improving remote medical service models.

2. Materials and methods

2.1. Study subjects

This study used a cross-sectional survey design and was conducted in southwestern China from January 2025 to January 2026. A total of 59 primary health care institutions that had established medical alliance cooperation relationships with our hospital were selected as the study subjects, including 46 township health centers and village clinics, and 13 district/county-level medical institutions and community health service centers. All included institutions had basic imaging examination conditions, but due to limitations in imaging professionals and diagnostic capacity, some examinations required remote support from higher-level medical institutions.

The survey respondents included primary health care institution administrators and primary care clinicians. This study was approved by the medical ethics committee (approval number 2024-MSY-EC-2024013), and all survey respondents provided informed consent.

2.2. Teleradiology service model

A teleradiology collaboration platform was established relying on the medical imaging center of our hospital, and the PACS system was used to enable the upload of primary-level imaging data, remote diagnosis, and report feedback. After receiving standardized training, primary-level imaging staff completed image acquisition. Radiologists in our hospital's Department of Radiology made remote diagnoses based on imaging data and clinical information, and conducted remote consultations for difficult cases.

2.3. Survey content and data collection

A questionnaire was designed based on health service supply-demand theory and medical trust theory. Primary health care institution administrators were mainly surveyed regarding imaging resource allocation, shortage of radiology professionals, and the impact of teleradiology on medical quality, number of patient visits, and medical alliance collaboration. Primary care physicians mainly evaluated the degree of dependence on imaging examinations for common diseases, primary-level imaging diagnostic capacity, and the supportive role of remote imaging in clinical diagnosis and treatment.

2.4. Statistical analysis

Descriptive statistical methods were used to analyze the survey results, and categorical variables were expressed as frequencies and percentages. Based on the theoretical framework of supply-demand matching and trust construction, a comprehensive analysis was conducted on the status of primary-level imaging resources, clinical imaging demand, and the application value of teleradiology.

3. Results

3.1. Current status of primary-level imaging resource allocation and supply capacity

A total of 55 primary health care institution administrators and 63 primary care physicians were ultimately included in the analysis. The shortage of imaging professionals in primary health care institutions was prominent. The survey of primary health care institution administrators showed that among 55 administrators, 47 (85.5%) believed that their institution had a shortage of radiology diagnostic personnel, while only 8 (14.5%) believed that this problem did not exist. Regarding the evaluation of the application value of teleradiology, 41 (74.5%) administrators believed that teleradiology could alleviate the shortage of primary-level imaging personnel, 44 (80.0%) believed that it helped improve medical quality, 53 (96.4%) believed that teleradiology could promote an increase in the number of patient visits, and 50 (90.9%) believed that it could strengthen clinical collaboration among medical alliance member institutions (see **Table 1**, **Figure 1**).

Table 1. Current status of imaging service supply in primary health care institutions and administrators' evaluation of the value of teleradiology

Imaging resource/attitude	Yes	Neutral	No
Whether there is a shortage of radiology diagnostic personnel	47	0	8
Whether remote imaging solves personnel shortage	41	13	1
Whether remote imaging improves medical quality	44	10	1
Whether remote imaging increases the number of patient visits	53	0	2
Whether remote imaging strengthens clinical cooperation among medical alliance member institutions	50	3	2

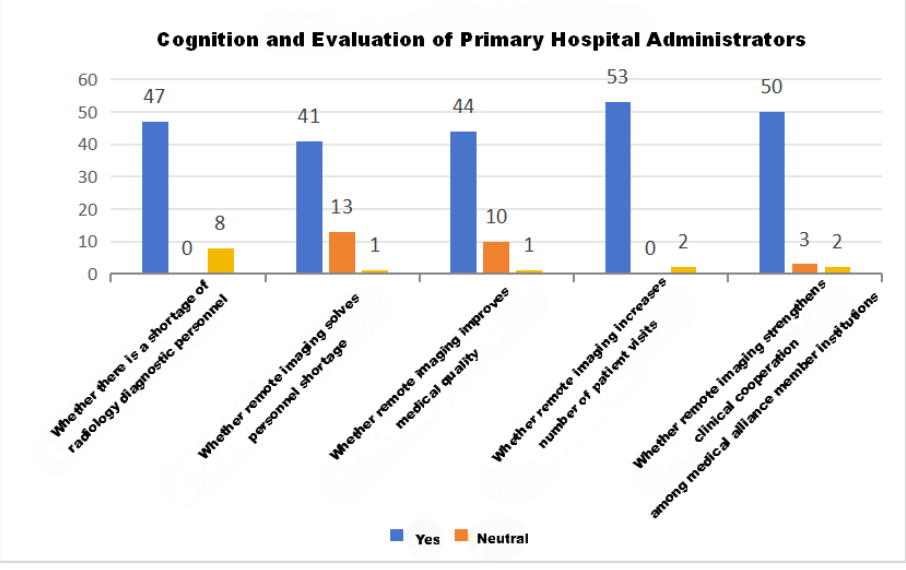


Figure 1. Primary health care institution administrators' cognitive evaluation of the current status of imaging services and the value of teleradiology.

3.2. Degree of dependence of primary-level clinical diagnosis and treatment on imaging services

The survey of primary care physicians showed that imaging examinations had become an important auxiliary tool for the diagnosis and treatment of common diseases at the primary level. For common diseases such as acute abdomen, pneumonia and pneumothorax, fracture, stroke, and myocardial infarction, primary care physicians had a high degree of dependence on imaging examinations.

Among them, the degree of imaging dependence was highest for fracture and stroke, both 62/63 (98.4%); pneumonia and pneumothorax were 61/63 (96.8%); acute abdomen was 59/63 (93.7%); and myocardial infarction was 53/63 (84.1%). The results suggest a clear mismatch between primary-level clinical diagnostic and treatment needs and imaging service capacity (see **Table 2**, **Figure 2**).

Table 2. Characteristics of primary-level clinical imaging demand and physicians' evaluation of the diagnostic and therapeutic support role of teleradiology

Common disease/degree of imaging dependence	High dependence	Moderate dependence	Low dependence
Acute abdomen	59	4	0
Pneumonia and pneumothorax	61	2	0
Fracture	62	1	0
Stroke	62	1	0
Myocardial infarction	53	6	4
Ability of primary hospital radiology department to solve problems	3	42	18
Ability of remote imaging to solve problems	56	6	1
Degree of help of remote imaging to patients	60	3	0

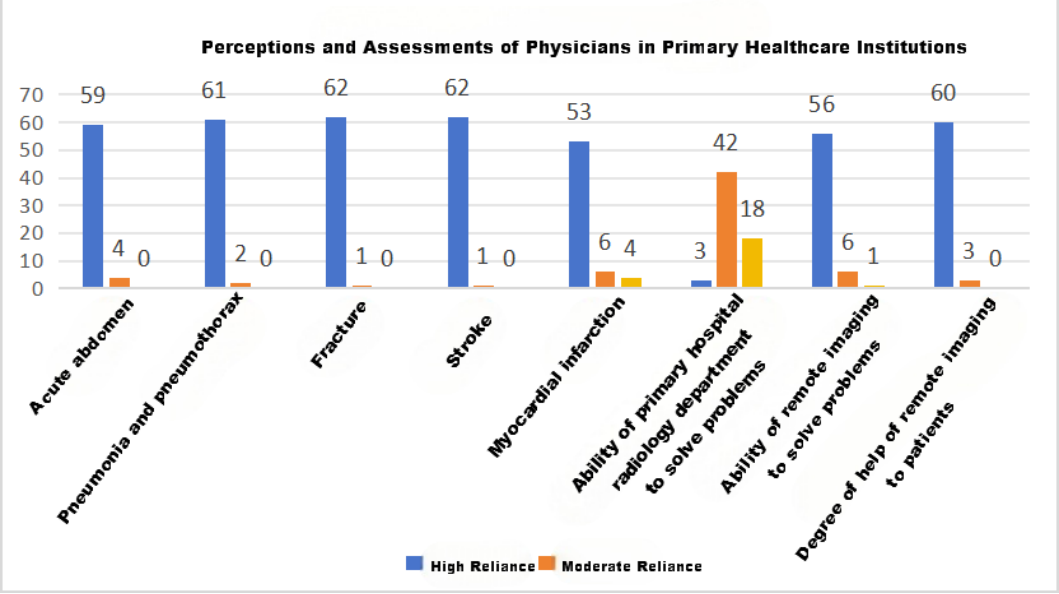


Figure 2. Primary care physicians' dependence on imaging service needs and evaluation of the diagnostic and therapeutic support role of teleradiology.

3.3. Impact of teleradiology on primary-level diagnostic and therapeutic support capacity

The evaluation of primary-level imaging diagnostic capacity by primary care physicians showed that only 3 physicians (4.8%) believed that primary health care institutions had strong independent problem-solving capacity for imaging diagnosis, 42 (66.7%) considered it to be at a moderate level, and 18 (28.6%) considered it to be low. In contrast, 56 primary care physicians (88.9%) believed that teleradiology could improve the problem-solving capacity for disease diagnosis at the primary level, and only 1 (1.6%) believed that the degree of help was low. At the same time, 60 physicians (95.2%) believed that remote imaging services could provide considerable help for patient diagnosis and treatment, suggesting that teleradiology plays a positive role in improving the accessibility of primary-level imaging services and clinical support capacity (**Table 2**).

3.4. Teleradiology promotes supply-demand matching of primary-level imaging services

Combining the survey results of primary care administrators and physicians, it was found that primary health care institutions generally had a mismatch between insufficient imaging professional resources and relatively high clinical diagnostic and treatment demand. On the one hand, the shortage of primary-level imaging professionals limited independent diagnostic capacity; on the other hand, primary care physicians had a high dependence on imaging examinations.

By connecting primary-level examination resources with the imaging diagnostic capacity of higher-level medical institutions, teleradiology compensated to a certain extent for the insufficient supply of primary-level imaging, improved the diagnostic and therapeutic support capacity of primary health care institutions for common and complex diseases, and realized the transformation of imaging resources from centralized allocation to regional collaborative utilization.

3.5. Impact of teleradiology on imaging diagnostic quality

After the implementation of teleradiology, the imaging diagnostic concordance rate increased from 58.3% to 91.7%, and the missed diagnosis rate decreased from 12.4% to 2.1%, suggesting that the remote imaging support model can improve the quality of primary-level imaging diagnosis and enhance diagnostic and therapeutic safety.

4. Discussion

4.1. Teleradiology alleviates the shortage of primary-level imaging resources and optimizes supply-demand matching of imaging services

This study found that the shortage of imaging professionals in primary health care institutions was prominent; 85.5% of primary care administrators believed that their institution had a shortage of radiology professionals. At the same time, primary care physicians had a high demand for imaging examinations, with the dependence rate on imaging examinations for common diseases reaching 84.1%–98.4%, suggesting an obvious supply-demand imbalance in primary-level imaging services. On the one hand, with population aging and the increasing burden of chronic diseases, the demand of primary health care institutions for imaging examinations and diagnostic support continues to grow; on the other hand, the long training cycle and uneven regional distribution of imaging professionals make it difficult for primary-level institutions to meet the growing demand for imaging diagnosis independently.

From the perspective of health service supply-demand theory, medical imaging services are highly

specialized and resource-dependent, and their supply capacity is limited by factors such as the number of imaging physicians, professional experience, and equipment conditions. Under the traditional model, high-quality imaging resources are mainly concentrated in large medical institutions. Although primary-level institutions have imaging examination conditions, their diagnostic capacity is insufficient, forming a structural contradiction of "examinations at the primary level, diagnosis at a higher level."

Teleradiology connects primary-level imaging acquisition sites with the diagnostic resources of higher-level hospitals through information technology, enabling imaging professional capacity to break through geographical limitations and realize a transformation from "centralized allocation of experts" to "sharing of diagnostic capacity." This study shows that most primary care administrators believed that teleradiology could alleviate the shortage of professionals and promote the improvement of medical quality, suggesting that this model has positive value in improving the allocation of primary-level imaging resources and enhancing supply-demand matching efficiency [17,18].

4.2. Teleradiology enhances primary-level imaging diagnostic and therapeutic capacity and promotes improvement of medical quality

Imaging diagnostic capacity is an important foundation for primary health care institutions to carry out standardized diagnosis and treatment. This study found that only 4.8% of primary care physicians believed that primary-level institutions had strong independent imaging diagnostic capacity, while 88.9% of physicians believed that remote imaging could improve the problem-solving capacity for disease diagnosis and treatment at the primary level, and 95.2% of physicians believed that remote imaging could provide help for patient diagnosis and treatment, indicating that teleradiology effectively compensated for the insufficient imaging diagnostic capacity at the primary level.

Previous studies have shown that teleradiology can improve the accessibility and diagnostic efficiency of primary-level imaging services through standardized image transmission, remote expert diagnosis, and quality control systems. In recent years, studies in resource-limited areas such as India have also shown that teleradiology combined with digital imaging technology can improve imaging service coverage in rural areas and alleviate the shortage of radiology professionals [19].

This study further found that after the application of teleradiology, the imaging diagnostic concordance rate increased from 58.3% to 91.7%, and the missed diagnosis rate decreased from 12.4% to 2.1%, suggesting that the remote imaging support model not only improves service coverage but may also improve the quality of primary-level imaging diagnosis. Its core value is not to replace primary care medical personnel, but to improve disease identification and clinical decision-making capacity at the primary level through a collaborative model of "primary-level examination capacity + remote diagnostic support."

4.3. Teleradiology promotes the construction of trust in primary care through capacity empowerment

The utilization of primary health care services depends not only on resource accessibility but is also affected by the degree of trust of patients and medical personnel in primary-level diagnostic and therapeutic capacity. From the perspective of medical trust theory, this study found that insufficient primary-level imaging diagnostic capacity may weaken primary care physicians' recognition of imaging results and affect patients' choice of primary health care services.

By introducing professional imaging support from higher-level hospitals, teleradiology improves primary care physicians' recognition of diagnostic results. This study shows that 92.9% of primary care physicians recognized the quality of remote imaging reports, suggesting that teleradiology can enhance the professional trust of primary care physicians. At the same time, 96.4% of primary care administrators believed that teleradiology could increase the number of patient visits, indicating that improved service capacity may further enhance patients' trust in primary health care institutions.

Therefore, the mechanism of teleradiology is not only reflected in image transmission and diagnostic support at the technical level, but more importantly, by improving the professional capacity of primary care, it promotes a virtuous cycle of "capacity improvement—trust enhancement—increased service utilization."

4.4. Teleradiology promotes the coordinated development of the primary health system and has value for promotion

This study shows that 90.9% of primary care administrators believed that teleradiology could strengthen medical alliance collaboration, suggesting that teleradiology is not only an imaging technology service but has also become an important tool for promoting the coordination of regional medical resources.

Insufficient medical imaging resources are a common challenge faced by primary health systems worldwide, especially in resource-limited areas, where insufficient imaging equipment and professionals limit primary-level disease diagnostic capacity. Related studies have pointed out that establishing regional imaging centers, strengthening the application of information technology, and developing remote imaging services are important strategies for improving imaging accessibility [20-23].

For China, teleradiology can serve as an important path to promote the channeling of high-quality medical resources to the primary level. Combined with medical alliance construction, regional imaging center construction, and artificial intelligence-assisted diagnosis, it can form a collaborative service model of "primary-level examination, regional diagnosis, and unified quality management." However, its long-term development still requires further improvement of supporting policies such as quality control, data security, responsibility determination, and payment mechanisms.

4.5. Study limitations and prospects

This study still has certain limitations. First, this study used a cross-sectional survey design, mainly evaluating the current application status of teleradiology and related influencing factors, and cannot fully infer causality. Second, the study subjects came from primary health care institutions in southwestern China, and the generalizability of the results to other regions still needs further verification in combination with local medical resource conditions. Third, this study was mainly based on evaluations by primary care administrators and physicians. Future research can further incorporate indicators such as patients' long-term medical-seeking behavior, medical costs, and health outcomes, and conduct multicenter, longitudinal follow-up studies. In the future, artificial intelligence-assisted diagnosis, regional imaging center construction, and health economics evaluation can be combined to further explore the long-term value of teleradiology in the primary health system.

5. Conclusion

Teleradiology serves as a means to address the scarcity of imaging resources at the primary care level. It

contributes to strengthening primary-level imaging service capacity through several channels: boosting diagnostic support capabilities, improving service delivery, and fostering greater medical trust. Drawing on empirical evidence from southwestern China, this study offers insights into how digital technologies can empower the development of the primary health system and improve the distribution of imaging resources.

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Disclosure statement

The authors declare no conflict of interest.

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