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Recruiting AI Tools to Empower the Public Health Systems in Rural and Tribal Regions of India: A Scoping Review

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Abstract

AI-driven solutions hold immense promise in transforming healthcare delivery in rural and tribal regions of India, where disparities persist despite advancements in the sector. This scoping review examines the role of AI tools in strengthening public health systems and improving healthcare outcomes in these underserved areas. A comprehensive literature search was conducted across PubMed, ScienceDirect, and Google Scholar, with studies screened using the "Covidence" tool. Thematic analysis of English-language articles published through December 2023 reveals that AI technologies can address critical gaps in healthcare access and service delivery. However, barriers such as inadequate digital infrastructure, limited technical expertise, and regulatory challenges hinder effective implementation. Collaborative efforts among policymakers, healthcare professionals, and technology developers are essential to overcoming these obstacles, with a focus on enhancing digital infrastructure, workforce training, and policy support. By optimizing resources, empowering healthcare workers, and streamlining service delivery, AI has the potential to revolutionize rural healthcare. This review provides key insights and recommendations to inform stakeholders and guide future AI-driven public health initiatives.

Keywords: Artificial Intelligence, Public health systems, Rural healthcare, Tribal regions, Healthcare equity

1 Introduction

The healthcare needs of rural populations are frequently overlooked due to insufficient medical infrastructure, resources, and healthcare professionals. With the rapid progression of Artificial Intelligence (AI) technology, there is increasing interest in utilizing AI to address the healthcare challenges encountered in rural areas. AI-driven healthcare solutions have the potential to enhance the accessibility, quality, and efficiency of healthcare delivery in these communities. Consequently, the healthcare industry is keen on implementing emerging AI technologies in rural settings. AI is an advancing domain of computer science that enables computers to mimic human learning, memory, analysis, and

innovation, which traditionally require human intelligence¹⁻³. AI is increasingly applied in the medical field to elevate the professional standard and efficiency of clinical work, as well as to prevent medical errors in rural regions⁴.

The rapid evolution of health information technology, including electronic medical records (EMR) and personal health records (PHR), has generated vast amounts of multimedia information in the form of documents, forms, images, and audio. Thus, the integration of AI technology is anticipated to assist patients⁵. AI-assisted clinical trials can manage large volumes of data and produce highly accurate results⁶. Medical AI companies are developing systems to

support patients at every stage of care. Clinical intelligence also analyzes patients' medical data, offering insights to enhance their quality of life⁷. Globally, healthcare systems grapple with significant challenges, such as lack of access, high costs, inefficiencies, and an aging population. Pandemics like COVID-19 further strain healthcare systems, leading to shortages of protective equipment, inadequate or inaccurate diagnostic tests, overburdened healthcare professionals, and insufficient information sharing.

In this review, we explore the various ways in which AI tools can empower public health systems in rural and tribal regions of India. The objective of this review was to search journal articles, review articles, and conference papers that discuss the role of AI in supporting healthcare in rural areas. We discuss the challenges of health services in rural areas, the prospects of medical AI technology, the potential roles of medical AI technology in rural and tribal areas, and the proposed medical AI technology service network.

2 Major Challenges of Health Care Services in Rural and Tribal India

In rural and tribal India, primary healthcare services are provided through a diverse and competitive marketplace characterized by a limited number of qualified MBBS-degree holders and a wide array of non-MBBS practitioners, including AYUSH providers and those with varied or no medical qualifications⁸. This situation significantly impacts healthcare diagnostics, with overburdened healthcare facilities and a scarcity of skilled practitioners compromising the quality of diagnostics. Rural and tribal areas face a stark disparity in healthcare infrastructure compared to urban counterparts, resulting in challenges such as limited ICU availability and the necessity for rural and tribal patients to travel to urban centers for diagnostics, particularly difficult for those from remote villages. Complex diseases like cancer present triaging challenges due to a shortage of specialized healthcare providers capable of interpreting diagnostic reports.

Moreover, disparities in healthcare access are pronounced across different socio-economic groups, notably affecting the management of chronic conditions like hypertension, heart disease, and diabetes. A substantial proportion of these conditions go untreated in rural and tribal areas due to inadequate local diagnostic facilities. For instance, while only 3% of major illnesses remain untreated in metropolitan areas, this figure rises to 12% in less developed villages and is even higher among scheduled tribes, where one-fifth of diagnosed major illnesses remain untreated⁹.

The current healthcare delivery system in rural and tribal India is beset by numerous challenges hindering the provision of quality care for chronic health conditions. Both public and private healthcare facilities exhibit doctor-centric care processes, with heavy workloads impeding effective patient

communication and counseling, particularly in the public sector. Fragmented health information systems further complicate patient follow-up and self-management, leaving patients largely unsupported in navigating the healthcare landscape¹⁰.

Efforts to improve healthcare accessibility through schemes like the National Rural Health Mission (NRHM) and Ayushman Bharat Digital Mission (ABDM) are hindered by inadequate infrastructure and a shortage of trained healthcare providers. Outpatient departments in rural government hospitals are consistently overcrowded, leading to prolonged wait times for registration, consultation, diagnostic tests, and medication, thereby disrupting patients' daily lives¹¹.

3 Prospects of Medical AI Technology

AI has become increasingly essential in clinical decision-making due to the exponential growth of medical knowledge, which doubles approximately every three years. Keeping abreast of this volume of information would require an impractical 29 hours per workday for physicians¹². Moreover, the integration of big data, encompassing electronic health records (EHRs), genomic data, and sociodemographic details, necessitates sophisticated analysis to be clinically valuable. AI technologies, exemplified by IBM Watson, play a pivotal role by leveraging machine learning and natural language processing to interpret EHRs and access relevant medical literature swiftly. Comparative studies indicate that AI systems such as Watson Oncology demonstrate high concordance rates, with 90% agreement in clinical recommendations compared to those made by tumor boards, achieved in mere seconds^{12,13}.

In the realm of EHRs, despite initiatives promoting their adoption, challenges persist including user dissatisfaction, interoperability issues, and uneven uptake among medical practices^{14,15}. AI offers potential solutions by automating data collection, organization, and personalized treatment planning, thus mitigating these operational hurdles¹⁶.

Diagnostic accuracy is critical in healthcare, where errors can have significant consequences. AI-driven technologies, particularly in radiology, are enhancing diagnostic precision by processing vast amounts of medical imaging data. Studies have shown AI's capability to diagnose conditions like skin cancer and breast cancer metastasis with performance comparable to or exceeding human experts, thereby improving diagnostic speed, accuracy, and consistency¹⁷⁻¹⁹.

Personalized medicine, reliant on individualized health data encompassing genetic, environmental, and lifestyle factors, benefits greatly from AI's data integration and analytical capabilities²⁰. These technologies are also integral to managing healthcare systems more effectively, offering tools

for monitoring patient health, optimizing resource allocation, and reducing unnecessary medical interventions, which can lead to overdiagnosis and overprescription issues²¹⁻²³.

In the realm of medical robotics, AI contributes to innovations such as telerobots for patient communication, surgical assistants like the da Vinci Surgical System, and various assistive devices that enhance patient care and surgical outcomes^{24, 25}.

4 Potential Roles of Medical AI Technology in Rural and Tribal Areas of India

As previously discussed, many rural and tribal areas in developing countries face a scarcity of trained physicians, necessitating the treatment of numerous patients by nurses or paramedical health workers. The challenges encountered are often straightforward, repetitive, and amenable to treatment with a limited range of essential medications. Initially termed computer-assisted medical technology, medical AI technology emerged as a pivotal advancement. In 1998, the Early Detection and Prevention System (EDPS), a computer-assisted diagnostic system, was introduced in India for rural and tribal clinics lacking physician presence. The EDPS provided guidance and recommendations to nurses and experienced paramedics. A study by the Kempegowda Institute of Medical Science in Bangalore, India, revealed a 94% overall consistency rate between the EDPS and physicians across 933 patients. Another study indicated positive patient feedback, noting perceived accuracy and enhanced interaction compared to traditional health personnel encounters, with village health nurses expressing interest in integrating such systems into practice²⁶.

Mobile Clinical Decision Support Systems (mCDSS) encompass various mobile electronic devices like phones, laptops, iPads, and wearables that offer medical guidance to health workers, enhancing healthcare quality. Adepoju *et al.* systematically reviewed mCDSS use in rural and tribal sub-Saharan Africa, finding limited evidence for overall healthcare quality improvement but noting benefits such as enhanced healthcare outcomes and reduced antibiotic over prescription. Health workers perceived improvements in efficiency, competence, and self-confidence, alongside strengthened patient-provider relationships through increased trust and confidence²⁷. Olajubu *et al.* suggested that full-scale mCDSS implementation could extend healthcare availability from urban to rural and tribal areas, potentially lowering mortality rates in vulnerable developing regions, particularly in Sub-Saharan Africa²⁸.

Recent advances in medical AI technology have also benefitted rural and tribal healthcare in China. A portable diagnostic station, weighing 11 pounds, performs 11 tests including blood pressure, electrocardiograms, and routine urine and blood

analyses. Developed under national rural and tribal healthcare support, this station uploads results and medical records to an online analysis system, offering diagnoses for review by village health workers. Major technology firms in China are investing in AI-driven smart clinics for rural and tribal regions, such as AI-powered chatbots that provide medical advice and deliver training to local health workers online²⁹.

Beyond primary healthcare, specialized AI systems have been developed for specific diseases in rural and tribal areas. For instance, a low-cost swallowable endoscopic capsule with AI analysis detects upper gastrointestinal cancers, suitable for settings where traditional screening is impractical or costly³⁰. In diagnosing acute leukemia, Escalante *et al.* demonstrated an AI method utilizing morphological analysis of bone marrow images, offering a cost-effective alternative to expensive diagnostic techniques in developing countries³¹. Similarly, a clinical decision support system for peripheral neuropathies by Kunhimangalam *et al.* achieved 93.3% accuracy compared to expert opinions, addressing diagnostic challenges in the absence of neurology specialists³². Oliveira *et al.* introduced an AI-based diagnostic system using mobile devices to analyze Giemsa-stained blood samples for malaria, achieving 91% accuracy on average³³. These innovations underscore the potential for low-cost diagnostic tools to overcome accessibility barriers in rural and tribal developing regions, replacing prohibitively expensive or unavailable traditional equipment.

In summary, medical AI technology enhances healthcare efficiency, quality, and cost-effectiveness, enabling nurses and paramedics to compensate for physician shortages. However, deploying isolated devices like mCDSS or portable diagnostic stations is insufficient. To elevate healthcare standards comprehensively in rural and tribal developing areas, effective medical AI systems necessitate robust infrastructural support (electricity, internet), ongoing training, supervision, financial backing, technical upgrades, and supportive public health policies²⁷. Therefore, this article proposes a comprehensive, multilevel medical AI service network to enhance healthcare availability and quality in rural and tribal developing regions.

5 Proposed Medical AI Technology Service Network for Rural and Tribal Areas of India

In the context of rural and tribal healthcare, it is imperative to tailor medical AI systems specifically for these settings. Here, we outline a hierarchical framework for a medical AI service network designed to meet these unique challenges.

(1) Foundational Tier - Frontline medical AI system:

This system is intended for use in the most fundamental rural healthcare facilities, such as village clinics. Given the constraints of poor economic conditions, limited transportation, unreliable communication and power

infrastructure, inadequate medical training, and prevalence of straightforward ailments, this system is characterized by: (a) an economical clinical decision support system focused on common diseases, with referrals recommended for complex cases; (b) affordability, aiming for a cost range INR 50,000 to 100,000; (c) a robust, portable design resistant to shock, sand, moisture, and water; (d) multiple connectivity options for information transmission and system updates (e.g., telephone, wireless, cable); (e) provision for rechargeable batteries or hand-cranked generators for power autonomy; and (f) a user-friendly interface requiring minimal training. Overall, this system typically comprises a laptop and portable diagnostic instruments capable of basic medical tests such as blood, urine, and ECG, integrated with AI for electronic health records (EHRs), diagnostic analysis, and clinical advice⁴.

(2) Regional Hub - Regional medical AI support centers:

These centers, located in county and regional hospitals, serve pivotal roles in training primary healthcare personnel, maintaining and upgrading frontline AI systems, and aggregating epidemiological data from primary EHRs. They may also house specialized AI systems for managing complex medical conditions.

(3) National Center - National medical AI development center:

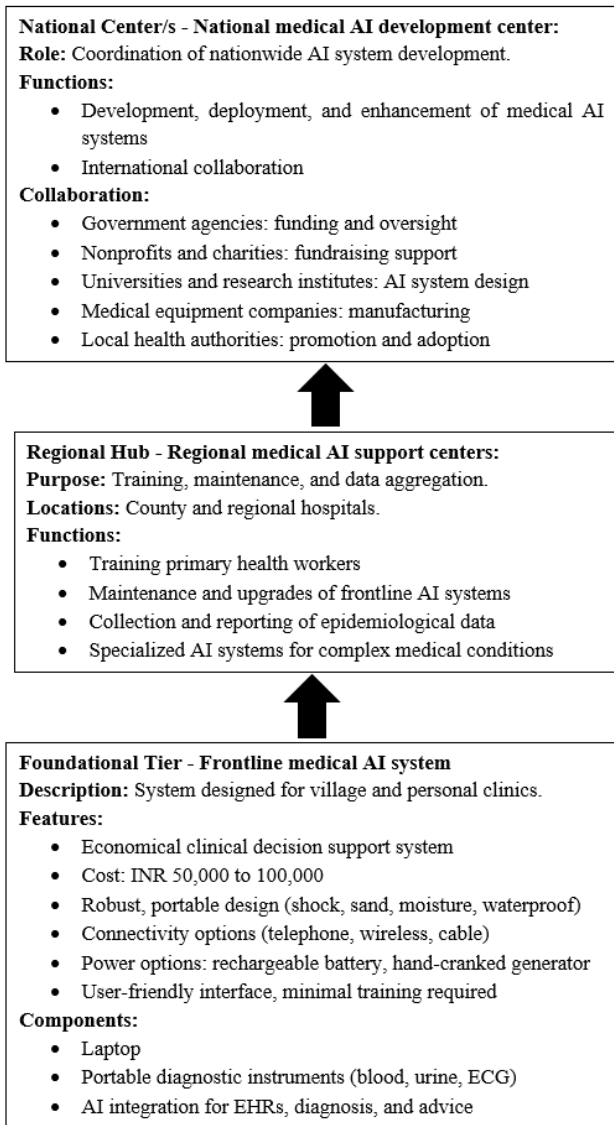
This central hub coordinates nationwide development, deployment, and enhancement of medical AI systems, fostering international collaborations. Effective operation of this multilevel network requires collaborative efforts: government agencies provide funding and oversight; nonprofits and charities assist in fundraising; universities and medical research institutes design AI systems; medical equipment companies manufacture devices; and local health authorities promote system adoption. Continuous cooperation among these stakeholders is essential to ensure the network remains current with medical advancements and technological progress.

This structured approach ensures that medical AI systems are optimally adapted to the unique challenges and requirements of rural and tribal healthcare environments, thereby enhancing accessibility and quality of healthcare delivery^{26, 34, 35}.

6 Existing Policies and Frameworks by Government in India

The Government of India has implemented several policies to promote the digitalization of healthcare facilities in rural areas and the use of Artificial Intelligence (AI) software. Key initiatives include the establishment of an AI Task Force, the formulation of a National Strategy for AI by NITI Aayog, and the creation of AI committees under the Ministry of Electronics

and Information Technology. State governments have also launched initiatives such as the Center of Excellence for Data Science and AI by Karnataka and the Safe and Ethical AI Policy 2020 by Tamil Nadu³⁶. These policies aim to accelerate the adoption of AI in rural healthcare settings across India.



Furthermore, the Indian government supports startups in the healthcare sector and encourages the development of AI-based software for healthcare needs. Premier institutions like the Indian Institute of Technology have played a pivotal role in nurturing healthcare startups focused on AI and emerging technologies. For instance, the Indian Institute of Technology, Mumbai has incubated Naima, an AI-based mobile application designed to monitor and mitigate pregnancy risks³⁷.

Collectively, these governmental initiatives and frameworks are expected to facilitate the widespread adoption of AI in rural healthcare throughout India.

In addition to these initiatives, the Government of India has launched the Ayushman Bharat Digital Mission (ABDM) to further support the digitalization of healthcare services across the country³⁸. ABDM aims to create a seamless and interoperable digital health ecosystem that includes electronic health records (EHRs), telemedicine services, and AI-driven healthcare solutions. This mission not only seeks to improve access to healthcare services but also promotes the integration of advanced technologies like Artificial Intelligence to enhance healthcare delivery in rural India. The ABDM initiative is part of the broader effort by the Indian government to leverage digital technologies for improving healthcare accessibility and quality nationwide.

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7 Conclusion

Medical artificial intelligence (AI) technology holds promise in enhancing healthcare accessibility and quality in rural areas of developing nations. To achieve this objective, we advocate for the establishment of a hierarchical medical AI service framework. This framework comprises a frontline medical AI system at the primary level, regional medical AI support centers at intermediary levels, and a national medical AI development center as the apex level. We propose sustained collaboration among governments, nonprofit entities, charitable organizations, university research institutes, AI firms, and medical equipment manufacturers for the continuous development, promotion, maintenance, and enhancement of this network. Furthermore, we suggest the establishment of a dedicated governmental health agency to oversee this initiative. This review aims to serve as a guide for international bodies such as the World Health Organization (WHO), the International Labour Organization, national health ministries, and other relevant stakeholders, facilitating advancements in healthcare delivery for patients in developing countries.

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