RESEARCH BRIEF

Bridging the Healthcare Gap:
Telemedicine and Digital Medical Tools in Hard-to-Reach Areas of Rajasthan

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KEY MESSAGES

- Telemedicine with ASHA/ANM support achieved 100% healthcare access in hard-to-reach areas of Barmer district, compared to only 38.5% in control villages relying on conventional care.
- 98.6% of teleconsultations were managed through customized telemedicine portal reducing long travel and out-of-pocket expenses for primary care.
- Digital diagnostic tools (BP monitors, pulse oximeters, portable ECG) demonstrated high clinical reliability with ICC >0.96, enabling safe, objective remote triage.
- An AI-driven Clinical Decision Support System (CDSS) achieved 90% validation accuracy, strengthening evidence-based prescribing in resource-constrained settings.
- Frontline health workers like Nurses, ASHAs and ANMs are essential for assisted telemedicine in providing door-step healthcare facility.

EXECUTIVE SUMMARY

Access to quality healthcare in hard-to-reach rural areas of India remains a critical public health challenge due to geographical barriers, shortages of healthcare professionals, and limited infrastructure. This leaves millions unable to access timely medical care. India faces a persistent shortage of skilled healthcare providers in rural areas, with approximately 74% of medical practitioners serving only 28% of the population. In rural areas, where 70% of the population resides, there is a wide lack of essential physical infrastructure. The burden on rural healthcare is intensified by the fact that 86% of all medical visits are made by rural residents, often travelling more than 100km. This logistical hurdle, along with predominant out-of-pocket spending, underscores the need for accessible, cost-effective healthcare solutions.

This policy brief presents findings from interventional study conducted by ICMR-NIHR Jodhpur, examining whether a frontline-worker-assisted telemedicine model supported by portable digital diagnostic tools, can transform healthcare delivery in hard-to-reach communities of Balotra district, Rajasthan.

The study's findings showed that while only 38.5% of symptomatic individuals in control villages accessed formal healthcare, 100% of those in telemedicine-enabled intervention villages received timely consultations. The major reasons for non-utilization of healthcare in control areas were geographical distance, limited availability of public transport followed by reliance on self-medication and home remedies. The evidence strongly supports scaling and institutionalising an assisted telemedicine model where trained frontline healthcare workers facilitate doorstep consultations using validated digital tools, as a sustainable, equitable strategy for primary healthcare delivery in hard-to-reach areas.

CURRENT SITUATION

India's rural population, approximately 65% of the total, faces a deeply unequal distribution of healthcare resources. In hard-to-reach areas, geographical distance, poor road connectivity, and limited public transport force communities to travel long distances for basic medical care, often at prohibitive cost and time. Rajasthan, India's largest state by area, has vast desert and semi-arid tracts where PHCs serve dispersed populations across challenging terrain. The Government of India's Telemedicine Practice Guidelines (2020) and the scaling of the eSanjeevani platform represent significant policy commitments. However, there is less evidence on the real-world implementation of telemedicine in extremely rural, hard-to-reach areas with poor connectivity and low digital literacy. There are critical gaps between policy intent and informed implementation about acceptability, treatment-seeking behaviour, and diagnostic utility of digital tools in such contexts.

SYSTEMIC GAPS AND BARRIERS IN ADOPTION

The National Rural Health Mission (NRHM) has introduced financial incentives and contractual appointments to retain skilled health workers. Furthermore, national telemedicine initiatives like e-Sanjeevani portal have been established to provide teleconsultations. Despite the potential of digital health to bridge healthcare access gaps, there lies significant individual, provider, systemic challenges that impedes its adoption. To find these gaps a pre-implementation scoping review (26 studies, PRISMA-ScR) and qualitative research (24 in-depth interviews) in Balotra district was conducted that identified a cluster of interacting barriers:

Structural Barriers	Provider Barriers	Patient Barriers
• Poor internet connectivity • Inadequate PHC equipment • Long travel distances • Fragmented funding	• Unfamiliarity with telemedicine interfaces • Inadequate training • Limitations of non-physical diagnosis	• Low digital literacy (especially older adults) • Health literacy gaps • Preference for in-person consultation

This current study find out the reasons of not visiting healthcare facility in control villages. Only 1,528 (38.5%) of the 3,973 tracked individuals who became ill were able to obtain proper healthcare, which had serious consequences in the control group villages. Nearly 2,445 people, or 61.5% of the total, did not receive professional medical care, reasons are shown in Figure 1 below:

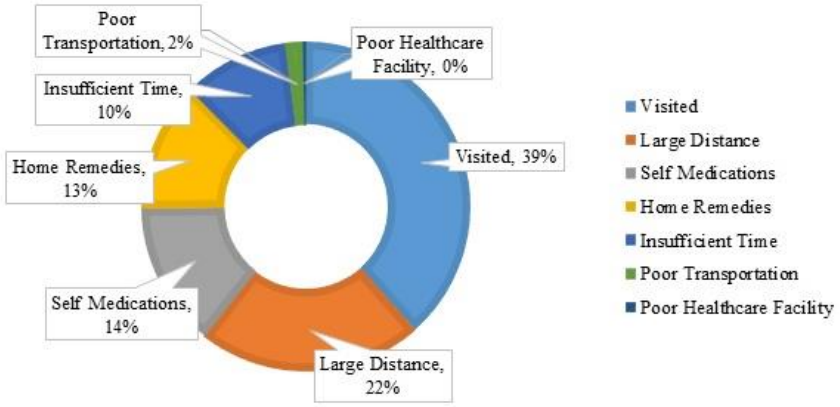

Figure 1. Treatment-seeking behavior and reported barriers to accessing healthcare facilities in control group.

ABOUT THE STUDY

Study Overview

An interventional study (IIRP-2023-0000151) was conducted by ICMR-NIHR, Jodhpur, in collaboration with IIT Jodhpur and Dr. S.N. Medical College over 22 months (March 2024 - Jan 2026) in 10 hard-to-reach villages within Balotra district, Rajasthan. Two PHCs, Siner PHC (Intervention Group) and Ramaniya PHC (Control Group) were randomly selected using Excel randomization function, each covering 5 study villages with a distance of >5km from healthcare facility.

Intervention: Intervention villages received: a frontline-worker-assisted telemedicine service (ASHA/ANM + Project Nurse with smartphone and medical kit) at the doorstep, real-time vital parameters were captured (BP, SpO_2, heart rate, 12-lead ECG), cloud-based customized teleconsultation portal, and AI-driven Clinical Decision Support System (CDSS) for doctors support.

Control: Control villages were monitored through weekly door-to-door surveys by ASHAs and Project nurses to observe routine treatment-seeking behaviour without any telemedicine intervention.

Study at a Glance

Study Design	Interventional
Setting	Balotra District, Rajasthan
Villages	10 (5 Intervention + 5 Control)
Project Duration	22 Months
Participants	8,374 Total
Intervention	4,401 individuals
Control	3,973 individuals
Teleconsultations	4,401 cases
Framework	CFIR + TAM
Funding	ICMR, Govt. of India

Workflow: These frontline workers facilitated teleconsultations at the patient's doorstep, conducting first-level physiological screening and transmitting real-time clinical data to a cloud-based platform for medical officer review and teleconsultation. The doctors were capable of doing live consultations, giving e-prescription and using live Chatbot for patient interaction and reports exchange

AI Integration

The telemedicine platform utilized an advanced, AI-driven Clinical Decision Support System (CDSS) with incremental learning capabilities to assist doctors with structured diagnostic outputs and clinical triage. The Figure 2 shows various treatment suggested with facility to correct with mediation of doctors.

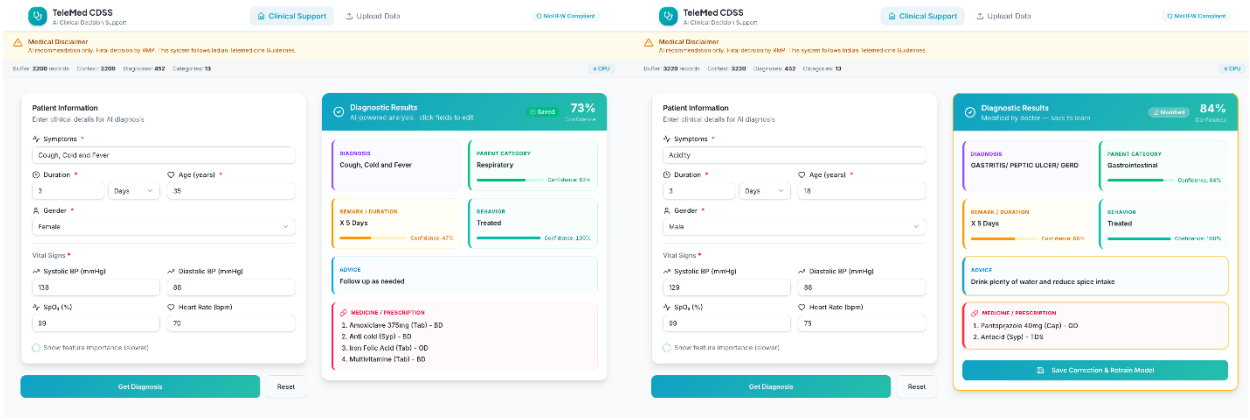

Figure 2. AI-CDSS suggestions based on patients symptoms with doctor mediation

KEY FINDINGS

Finding 1: Multifaceted Barriers Demand a Systems Approach

A PRISMA-ScR guided scoping review of 26 studies and analysis of 24 in-depth qualitative interviews with healthcare providers and patients revealed that barriers to telemedicine adoption in hard-to-reach areas are interconnected across structural, individual, provider, and system levels. There is no single-point solution that could fill this healthcare gap, so an assisted telemedicine model with Real time vital monitoring right at the doorstep of patient is required.

Finding 2: Acceptance of Tekemedicine Services

Using a mixed-methods approach with 28 participants (Medical Officers, nursing staff, ASHAs, ANMs, and patients), the study assessed acceptance through the Consolidated Framework for Implementation Research (CFIR) and Technology Acceptance Model (TAM):

Facilitators of Acceptance	Concerns
• Substantial reduction in travel burden and out-of-pocket expenses • Access to specialist consultations without travel • Doorstep care convenience • ANM/ASHA workers built trust and explained prescriptions in local languages • Culturally appropriate facilitation for female patients • Higher engagement rate in intervention villages	• Diagnostic limitations for dermatological and emergency cases • Antenatal cases requiring direct physical examination • Need for continued digital literacy support • Connectivity variability in remote areas

Finding 3: Transforming Treatment-Seeking Behaviour

INTERVENTION GROUP

100%

Symptomatic individual seeking medical care received timely teleconsultation and e-prescription

98.6% managed via teleconsultation only

1.4% referred to higher facility

36% follow-up visits with sustained continuity of care

CONTROL GROUP

38.5%

Of symptomatic individuals accessed physical healthcare facility

61.5% received no structured treatment

$\chi^2 = 3825.28$, df = 6, $p < 0.001$

Mann-Whitney U = 3,362,364, $p < 0.001$

Finding 4: Reliability of Digital Diagnostic Tools

The integration of clinically validated point-of-care diagnostic devices (Omron Bluetooth BP monitor, pulse oximeter, Spandan 12-lead ECG) integrated within the telemedicine workflow allowed remote medical officers to access accurate clinical data, enhancing diagnostic confidence. Apart from vital parameter, on-site cardia screening was done via portable 12-lead ECG to identify abnormal patterns, psychometric properties are displayed below:

ICC: Systolic BP	ICC: Diastolic BP	ECG Abnormalities	AI-CDSS Accuracy
0.972	**0.964**	**21.6%**	**90%**
95% CI: 0.967–0.977	95% CI: 0.954–0.973	Detected in cardiac cases (n=74)	Validation accuracy at 4,400 records for 100 test cases

POLICY IMPLICATIONS

Implication 1: ASHA/ANM as the backbone of digital health

The study proves that a standalone, patient-to-doctor telemedicine model is insufficient in hard-to-reach areas. Frontline healthcare workers are indispensable

Implication 4: Strengthen digital and physical infrastructure

Connectivity variability and portal stability emerged as ongoing implementation challenges. Without investment in reliable internet, and device

mediators because they build trust, resolve language barriers, operate medical devices, and ensure continuity of care. Policy should invest in development of an assisted telemedicine framework where frontline healthcare workers has a role digital health facilitators right at the doorstep of individuals.

Implication 2: Integrate Digital Point-of-Care Diagnostics

The real-time transmission of BP, SpO_2, heart rate, and ECG readings from patients' doorsteps significantly enhanced diagnostic confidence compared to symptom-based teleconsultations alone. Hence, healthcare workers equipped with clinically validated point-of-care diagnostic tools at the community level should be a prerequisite for safe, effective remote triage.

Implication 3: AI can be both safe and locally relevant

The TeleMed CDSS, grounded in 4,401 local patient records, provides evidence-based recommendations while requiring final validation and clinical authority by registered medical officers. This hybrid AI-human model ensures safety, builds local evidence, and reduces diagnostic variability in hard-to-reach areas.

maintenance, even the best clinical model cannot be sustained. In rural and hard-to-reach areas to perform seamless teleconsultation operations digital infrastructure should be developed.

Implication 5: Telemedicine reduces financial hardship

Cost of travel to distant healthcare facilities is one of the leading causes of delayed or foregone care. The telemedicine model demonstrated that doorstep care, facilitated by frontline workers, can eliminate this barrier by contributing to broader financial protection goals under Ayushman Bharat. The current e-Sanjeevani model can be updated to work at doorstep of individuals seeking care, may be for primary treatment.

Implication 6: Evidence gaps in gender-responsive telemedicine design

Female patients showed greater hesitancy toward direct teleconsultation without a trusted female ANM/ASHA as intermediary. Future telemedicine models and policies must be designed with gender sensitivity, ensuring women in hard-to-reach areas can access care with dignity and comfort. Also, specialized care rooms should be provided to ANMs for observation during their teleconsultation.

POLICY RECOMMENDATIONS

The following recommendations are presented for consideration by policymakers, programme managers, and health system leaders at the state and national levels:

01	**Scale the Assisted Telemedicine Model:** Transition from a standalone patient-to-doctor model to a frontline healthcare worker-assisted telemedicine model in all hard-to-reach PHC areas. Nurses and ANMs, equipped with smartphones and portable diagnostic kits, should serve as active health intermediaries and not passive referrers. This model should be piloted at district level before state-wide scale-up.
02	**Integrate Portable Diagnostic Kits into ANMs/Nurses Toolkits:** Standard ANM/Nurses field kits should be upgraded to include clinically verified digital diagnostic devices. Standard operating procedures for their use in community-level triage and teleconsultation should be developed and embedded in training curricula.
03	**Invest in Connectivity and Telemedicine Infrastructure:** Reliable, affordable internet connectivity is non-negotiable for telemedicine delivery. Government should prioritize expansion of seamless 4G/5G connectivity to hard-to-reach PHC areas under BharatNet and related programmes. Telemedicine portals should be optimized for low-bandwidth operation.
04	**Institutionalize Digital Health Training for Frontline Workers:** A structured, nationally-standardized, skill-based training programme for ANMs/Nurses in telemedicine facilitation, digital device operation, and teleconsultation support should be developed and mandated. This should be

	integrated into frontline healthcare worker training modules under the National Health Mission, with refresher training embedded as needed.
05	**Embed AI-CDSS in Public Telemedicine Platforms:** The AI-driven Clinical Decision Support System, trained on locally validated patient data, should be integrated into state and national telemedicine platforms to support evidence-based diagnosis. The system must remain a decision-support tool only and final clinical authority must always vest with the Registered Medical Practitioner, in compliance with Telemedicine Practice Guidelines 2020.
06	**Facilitation of Supervision, Monitoring, and Management at the Local Level:** The current telemedicine model supports supervision, monitoring, and management at the local level through dedicated administrative access. It also enables facility management and healthcare worker mapping. However, eSanjeevani does not provide portal access at the block or district level, limiting access to the state level only. Extending access to local levels is essential for effective monitoring and oversight.
07	**Expand and Evaluate at District Level:** This ICMR-NIHR model should be extended from the current 10-village study at district-level as a district-level scaled up, followed by evaluation across multiple agro-climatic and socio-cultural contexts within Rajasthan. This will generate and strengthen the evidence-base needed for state-wide or national scale-up with context-adapted modifications in the existing telemedicine model

THE WAY FORWARD

The current assisted telemedicine model, having demonstrated 100% healthcare access against only 38.5% in control villages, must be scaled up across all hard-to-reach areas of the district as an immediate priority, enabling context-specific strategies for scaled implementation. Accordingly, this frontline-worker-assisted model should be formally incorporated into the eSanjeevani national platform, where trained ANMs and Nurses can facilitate telemedicine in community settings within hard-to-reach areas, equipped with validated digital diagnostic tools, including BP monitors, pulse oximeters, portable ECG devices etc., to capture vital parameters in real time at the patient's doorstep/communities. Furthermore, the AI-driven Clinical Decision Support System (AI-CDSS), which has achieved 90% validation accuracy using 4,401 locally sourced patient records, should be integrated into the eSanjeevani platform under appropriate regulatory oversight, always operating as a decision-support tool with final clinical authority vested in registered medical practitioners as per the Telemedicine Practice Guidelines 2020. To ensure effective oversight and programme management, eSanjeevani portal access must be extended to the block and district levels, moving beyond the current state-level-only access, enabling local authorities to monitor, supervise, and manage telemedicine operations and facility mapping. These four pillars, district-wide scale-up across hard-to-reach areas, ANM/Nurse-assisted community telemedicine within eSanjeevani, AI-CDSS integration under regulation, and local-level portal access, collectively form the actionable roadmap for transforming primary healthcare delivery in India's hard-to-reach areas.

CONCLUSION

This study provides complete evidence that doorstep assisted telemedicine delivered by trained Nurses/ANM workers using clinically verified portable digital diagnostic tools within a structured, platform-supported model is capable to transform healthcare access in India's hard-to-reach areas. The high acceptance of healthcare access achieved via teleconsultation in intervention villages, compared to normal care in control areas, represents a profound and statistically unequivocal demonstration of impact. Telemedicine alone is not enough. The model works because of the human infrastructure it is built upon that includes frontline healthcare workers who build trust, bridge digital divides, took care to doorstep of needful and bring care to people who would otherwise go without. Scaling this model requires investing in people as much as in technology, training and infrastructure.

Acknowledgements

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