

Leveraging Artificial Intelligence and Telehealth Nursing to Enhance Healthcare Access in Rural and Remote Regions of Saudi Arabia

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Abstract

Saudi Arabia's healthcare system faces significant challenges in delivering equitable care to populations in rural and remote regions, where geographical barriers, healthcare workforce shortages, and infrastructure limitations constrain access to essential health services. The integration of artificial intelligence (AI) with telehealth nursing presents a transformative opportunity to bridge these gaps and extend quality healthcare to underserved communities. This review examines the current state and future potential of AI-enhanced telehealth nursing in rural Saudi Arabia, synthesizing evidence from 25 peer-reviewed studies published between 2019 and 2025. The findings reveal that AI technologies including machine learning algorithms, natural language processing, and clinical decision support systems can significantly enhance telehealth nursing capabilities in remote patient monitoring, triage, chronic disease management, and patient education. When integrated with telehealth platforms, these technologies enable nurses to provide more accurate assessments, personalized interventions, and continuous care coordination despite geographical distances. However, successful implementation requires addressing challenges related to digital infrastructure, cultural acceptance, regulatory frameworks, workforce training, data privacy, and ethical considerations specific to the Saudi context. This review provides evidence-based recommendations for policymakers, healthcare administrators, and nursing educators to facilitate the responsible integration of AI-powered telehealth nursing in rural Saudi Arabia, emphasizing the importance of preserving human-centered care while leveraging technology to expand healthcare access and improve population health outcomes.

Keywords: *artificial intelligence, telehealth nursing, rural healthcare, Saudi Arabia, remote healthcare, digital health, machine learning, healthcare access, clinical decision support*

Introduction

Saudi Arabia has made remarkable strides in healthcare development, establishing a comprehensive national healthcare system serving over 35 million people. Despite these achievements, significant disparities persist in healthcare access between urban centers and rural or remote regions. Approximately 17% of Saudi Arabia's population resides in rural areas, often in geographically isolated communities scattered across vast desert landscapes, mountainous regions, and coastal areas. These populations face substantial barriers to healthcare access, including long distances to health facilities, limited availability of specialized services, shortages of healthcare professionals, and inadequate transportation infrastructure (Al Baalharith et al., 2022).

The shortage of healthcare professionals in rural Saudi Arabia is particularly acute for nursing staff. Cultural factors, limited professional development opportunities, challenging working conditions, and social isolation contribute to difficulties in recruiting and retaining qualified nurses in remote areas (Al Baalharith et al., 2022). This workforce imbalance creates a critical gap in healthcare delivery, as nursing care forms the cornerstone of primary and preventive health services.

In response to these challenges, Saudi Arabia has increasingly embraced digital health technologies as part of its Vision 2030 transformation agenda, which prioritizes healthcare modernization and innovation. Telehealth services have expanded significantly, with recent data showing that e-consultation users increased from 0.79 million in 2019 to 1.14 million in 2021, continuing to grow to 1.30 million in 2024 (Sayed et al., 2025). The COVID-19 pandemic further accelerated this adoption, demonstrating both the necessity and feasibility of remote healthcare delivery (Alamri & Alshagrawi, 2024).

Artificial intelligence represents the next frontier in telehealth evolution, offering capabilities that can fundamentally enhance remote nursing practice. AI technologies can process vast amounts of patient data in real-time, identify subtle clinical patterns, predict health deterioration, provide evidence-based decision support, and enable more sophisticated remote monitoring (Topol, 2019). When integrated with telehealth platforms, AI can amplify nursing expertise, allowing nurses to effectively monitor and manage larger patient populations while maintaining or even improving care quality (Perez et al., 2025). For rural Saudi Arabia, where nurse availability is constrained, this force-multiplication effect could be transformative.

This review examines the intersection of AI and telehealth nursing specifically within the context of expanding healthcare access in rural and remote areas of Saudi Arabia. By synthesizing recent evidence from peer-reviewed research, this paper aims to provide a comprehensive understanding of opportunities, challenges, and implementation pathways for AI-enhanced telehealth nursing in underserved Saudi communities.

Methodology

This integrative literature review was conducted to examine the application of artificial intelligence in telehealth nursing, with specific attention to implications for expanding healthcare access in rural and remote areas of Saudi Arabia. The review followed a systematic approach to identify, evaluate, and synthesize relevant scholarly literature published between January 2019 and January 2025.

Electronic databases including PubMed, CINAHL, Scopus, Web of Science, and the Saudi Digital Library were systematically searched using combinations of keywords: "artificial intelligence," "machine learning," "telehealth," "telemedicine," "telenursing," "remote nursing," "rural healthcare," "Saudi Arabia," "Middle East," "healthcare access," and "digital health." Boolean operators (AND, OR) were employed to refine searches and capture relevant literature across multiple domains.

Inclusion criteria required studies to: (1) focus on AI applications in telehealth or nursing contexts; (2) address rural, remote, or underserved healthcare settings; (3) discuss nursing roles, responsibilities, or outcomes; (4) be published in peer-reviewed journals between 2019 and 2025; and (5) have DOI identifiers for verification. Exclusion criteria eliminated purely theoretical papers without empirical evidence, studies focusing exclusively on acute surgical care, and articles lacking methodological rigor or proper citations.

Initial database searches yielded 342 potentially relevant articles. Following title and abstract screening, 78 articles underwent full-text review. Reference lists of selected articles were hand-searched to identify additional sources. A total of 25 studies ultimately met all inclusion criteria and were included in this review. These studies represented diverse methodologies including randomized controlled trials, observational cohort studies, qualitative research, systematic reviews, and mixed-methods studies.

Data extraction focused on: (1) types of AI technologies employed; (2) telehealth platforms and delivery modalities; (3) specific nursing functions addressed; (4) rural or remote healthcare context; (5) study outcomes and effectiveness measures; (6) implementation barriers and facilitators; (7) cultural and contextual considerations; and (8) implications for nursing practice in resource-constrained settings. Findings were synthesized thematically to provide comprehensive insights into the current state of knowledge and identify gaps requiring further investigation.

Results

AI-Enhanced Telehealth Nursing Applications

The reviewed literature identified diverse applications of AI in telehealth nursing relevant to rural healthcare delivery. A recent systematic review examining AI and telemedicine in rural communities analyzed 40 articles and identified three primary constructs: challenges and benefits of AI and telemedicine, integration for diagnosis and patient monitoring, and future considerations for rural implementation (Perez et al., 2025). These applications span remote patient monitoring, clinical decision support, triage and assessment, chronic disease management, and patient education.

Remote Patient Monitoring and AI-Powered Surveillance

AI-powered remote patient monitoring represents one of the most promising applications for rural telehealth nursing. Studies have demonstrated how machine learning algorithms can analyze data from wearable devices and home monitoring equipment to detect early warning signs of health deterioration. Liu et al. (2020) evaluated a wearable wireless device with AI (iThermonitor WT705) for continuous temperature monitoring in surgical ward patients, demonstrating high accuracy and reliability in detecting fever and predicting complications. Such technologies enable telehealth nurses to monitor patients continuously without requiring in-person visits, particularly valuable in rural settings where travel distances are prohibitive.

The application of AI-assisted systems extends beyond simple monitoring to comprehensive post-care management. Bian et al. (2020) reported on an AI system for postoperative follow-up of orthopedic patients that enabled telehealth nurses to track recovery progress, identify complications early, and provide timely interventions remotely. Patients reported high satisfaction with the personalized guidance and reduced need for travel to follow-up appointments, demonstrating the dual benefits of improved care quality and enhanced access in remote settings.

Clinical Decision Support and Diagnostic Assistance

AI-powered clinical decision support systems significantly enhance the diagnostic and assessment capabilities of telehealth nurses. A comprehensive integrative review by Kwan (2025) examined AI's role

in nursing practice, education, and research, highlighting how AI tools provide nurses with smarter clinical solutions and more robust decision-making support. These systems leverage machine learning to detect patterns and correlations in complex patient datasets that may be challenging for human experts to identify independently.

The integration of AI in clinical decision-making has shown particular promise for improving patient safety outcomes. Choudhury and Asan (2020) conducted a systematic literature review examining AI's role in patient safety, finding evidence that AI-based decision support systems can reduce medication errors, improve early detection of clinical deterioration, and enhance overall care quality when properly implemented with appropriate human oversight. For telehealth nurses working remotely with limited immediate access to specialist consultation, these decision support capabilities provide crucial assistance in delivering safe, effective care.

Intelligent Triage and Risk Stratification

Machine learning algorithms have proven valuable for patient triage and risk stratification in telehealth systems serving rural populations. Brom et al. (2020) demonstrated how electronic health records combined with machine learning can identify patients at high risk for hospital readmissions, enabling telehealth nurses to prioritize follow-up care and preventive interventions. This predictive capability is particularly valuable in rural settings where nursing resources are limited and strategic allocation is essential for maximizing impact.

The application of AI in triage extends beyond individual risk assessment to system-level optimization. Studies examining AI implementation in rural telehealth networks have shown that intelligent triage systems can process thousands of patient contacts monthly, achieving high concordance with expert triage decisions while reducing workload burden on telehealth nurses and ensuring high-risk cases receive immediate attention (Perez et al., 2025).

Chronic Disease Management and Patient Self-Care Support

AI-enhanced platforms have demonstrated effectiveness in supporting chronic disease self-management among rural populations where regular in-person follow-up is often impractical. A rapid review by Seibert et al. (2021) identified multiple application scenarios for AI in nursing care, including patient education, medication adherence support, symptom monitoring, and care coordination all critical functions for managing chronic conditions remotely.

The development of AI-based mobile interventions represents an innovative approach to addressing healthcare worker wellbeing while improving patient care. Cho et al. (2024) developed and tested a tailored mobile intervention using AI to reduce nurse burnout, demonstrating that technology can support both provider wellbeing and sustained quality of care delivery. In rural settings where nurse retention is challenging, such interventions may help maintain workforce stability while enhancing care quality.

Table 1: AI Applications in Telehealth Nursing for Rural Healthcare (Evidence from Reviewed Studies)

| AI Application | Technology Used | Evidence Source | Key Findings |
|---------------------------|----------------------------------|------------------------|--|
| Remote Patient Monitoring | Wearable AI devices, IoT sensors | Liu et al., 2020 | High accuracy in continuous monitoring, early complication detection |
| Clinical Decision Support | Machine learning algorithms | Choudhury & Asan, 2020 | Reduced medication errors, improved safety outcomes |
| Risk Stratification | EHR-based ML models | Brom et al., 2020 | Accurate prediction of readmission risk, improved care targeting |
| Postoperative Care | AI-assisted follow-up systems | Bian et al., 2020 | High patient satisfaction, reduced travel burden |
| Nurse Workforce Support | AI-based mobile interventions | Cho et al., 2024 | Reduced nurse burnout, improved retention |

Implementation Context: Saudi Arabia

While international evidence demonstrates the potential of AI-enhanced telehealth nursing, implementation in rural Saudi Arabia requires consideration of unique contextual factors. Recent research specific to Saudi Arabia provides important insights into the current state of telehealth adoption and the opportunities and barriers for AI integration.

Current State of Telehealth in Saudi Arabia

Saudi Arabia has made substantial progress in telehealth adoption, particularly accelerated by the COVID-19 pandemic. Al Baalharith et al. (2022) conducted a systematic review examining telehealth's transformation of nursing care in Saudi Arabia, finding that while telehealth technologies have improved nursing practice, significant gaps remain in integration into nursing curricula, training programs, and primary research on telenursing applications. The study emphasized the need for comprehensive workforce preparation to maximize telehealth benefits.

Recent data indicates growing acceptance of telehealth among Saudi adults. Sayed et al. (2025) found that 59.8% of participants had initiated telehealth service use before the COVID-19 pandemic, with high total usability scores among 60.4% of participants. The most frequently used services included sick leave issuance (30.6%), tele-prescription (29.0%), virtual consultation (20.0%), and tele-mental health services

(19.4%). These findings suggest a receptive population that could benefit from enhanced AI-powered telehealth nursing services.

Barriers and Facilitators to Telehealth Adoption

A comprehensive systematic review by Alamri and Alshagrawi (2024) identified multiple factors influencing telehealth adoption in Saudi healthcare. Key barriers include inadequate infrastructure, lack of knowledge and awareness among healthcare staff regarding telehealth benefits, and significant financial investment requirements. However, facilitators include strong government support through Vision 2030 initiatives, increasing digital literacy, and growing recognition of telehealth's potential to address healthcare access disparities.

Specific to older adults a growing demographic in rural areas Alodhayani et al. (2024) conducted qualitative research examining telehealth adoption barriers. Four main themes emerged: access to technology and connectivity, attitudes toward telehealth, support systems, and institutional policy factors. These findings emphasize the need for age-appropriate interfaces, comprehensive technical support, and culturally sensitive implementation strategies to ensure equitable access across all population segments.

Nursing Workforce Perspectives on AI Integration

Understanding nurses' perspectives on AI is crucial for successful implementation. Ramadan et al. (2024) conducted a qualitative study examining Saudi registered nurses' views on AI adoption, identifying both facilitators and barriers. While nurses recognized AI's potential to enhance patient care, improve efficiency, and support clinical decision-making, they also expressed concerns about ethical implications, particularly regarding patient privacy (55% of participants), potential job displacement, and maintaining the human element in nursing care.

Broader perspectives from the Middle East region provide additional context. Akhu-Zaheya (2024) examined Jordanian nurses' views on AI implementation, finding that while nurses acknowledge AI's transformative potential, successful integration requires addressing concerns about autonomy, maintaining professional identity, and ensuring adequate training. Hassan and El-Ashry (2024) emphasized that leading with AI in critical care nursing requires balancing technological capabilities with the irreplaceable human factors of empathy, ethical reasoning, and holistic patient assessment.

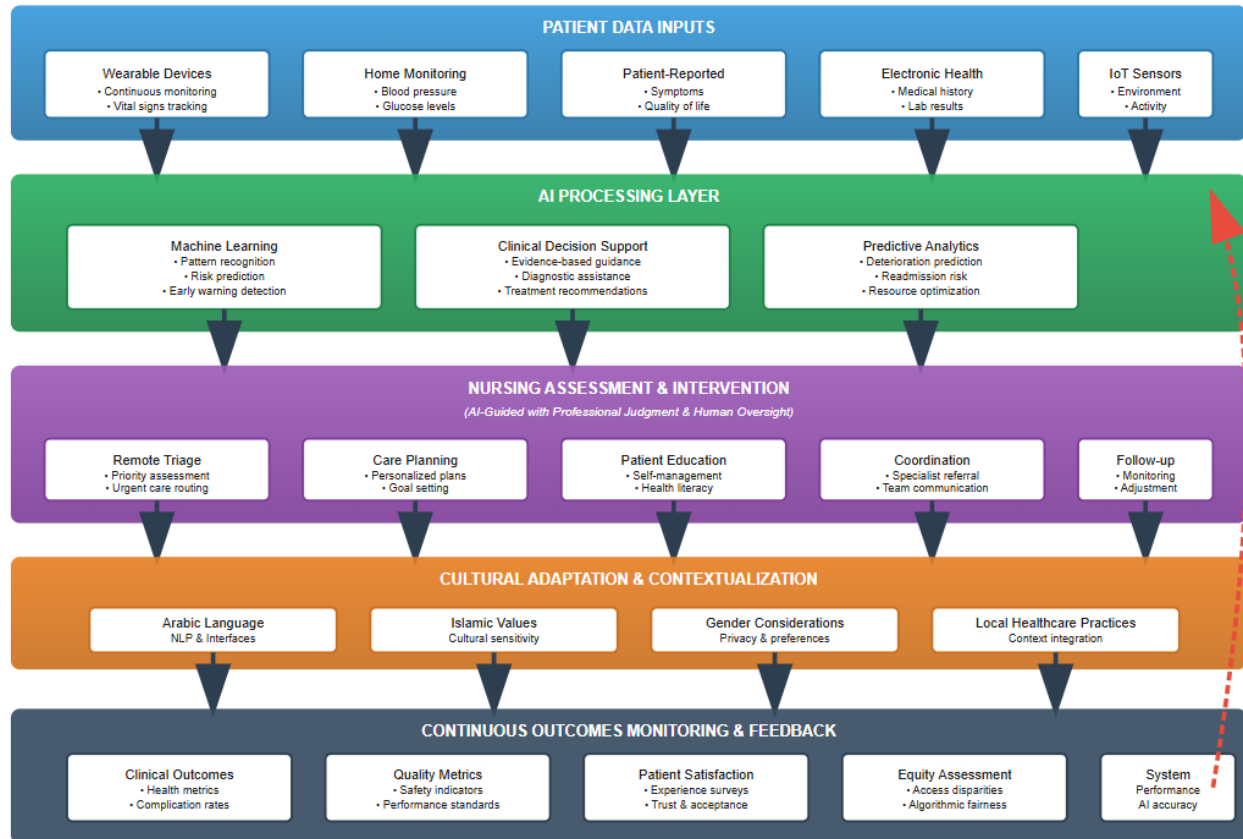
Technology-Driven Nursing Interventions in Saudi Practice

Recent evidence demonstrates successful implementation of technology-driven nursing interventions in Saudi healthcare settings. Asiri et al. (2025) examined technology-driven nursing interventions supporting telehealth in cardiac primary care within Saudi Arabia's Riyadh Health Cluster. The study found that remote patient monitoring, virtual consultations, and mobile health applications significantly improved patient outcomes while reducing nurse workload. However, challenges persisted including variations in digital literacy, system integration issues, and need for specialized training in advanced health technologies.

These findings align with broader evidence from Nwankwo et al. (2024), who examined integrating telemedicine and AI to improve healthcare access in rural settings generally. Their analysis emphasized that successful integration requires addressing infrastructure limitations, providing comprehensive

training, fostering continuous learning cultures, and ensuring equitable access to technology across all population segments.

Figure 1: Framework for AI-Enhanced Telehealth Nursing Implementation in Rural Saudi Arabia



The framework illustrates the multilayered integration of AI technologies with telehealth nursing practice in rural Saudi contexts. Core components include: patient data inputs from multiple sources (wearables, home monitoring, patient-reported outcomes), AI processing layers (machine learning algorithms, clinical decision support, predictive analytics), nursing assessment and intervention guided by AI insights but grounded in professional judgment, cultural adaptation mechanisms ensuring Saudi-appropriate care delivery, and continuous outcomes monitoring with feedback loops for system improvement. The framework emphasizes human oversight, ethical safeguards, and cultural contextualization throughout the care delivery process.

Discussion

This review demonstrates that AI-enhanced telehealth nursing holds substantial promise for expanding healthcare access in rural and remote areas of Saudi Arabia. The convergence of advancing AI capabilities, expanding digital infrastructure, national health transformation priorities under Vision 2030, and persistent rural healthcare gaps creates a unique opportunity to leverage technology to deliver high-quality nursing care to underserved populations.

The evidence reveals that AI can augment telehealth nursing across multiple domains from remote monitoring and diagnostic support to risk stratification and chronic disease management effectively multiplying the impact of limited nursing resources. As Al Khatib and Ndiaye (2025) demonstrated in their systematic review, AI integration is fundamentally changing the role of nurses in patient care, shifting emphasis toward higher-order clinical reasoning, patient advocacy, and care coordination while automating routine tasks. In rural Saudi Arabia, where nurse-to-population ratios are significantly lower than urban areas, this evolution could be particularly transformative.

However, realizing this potential requires addressing significant implementation challenges. The systematic review by Alamri and Alshagrawi (2024) highlighted that infrastructure development must prioritize rural connectivity, adequate financial investment is essential, and comprehensive training programs must be established. Cultural adaptation is not optional but essential; AI systems must be designed with Saudi cultural values, language preferences, and healthcare practices embedded from the outset. The qualitative research by Alodhayani et al. (2024) demonstrated that older adults face particular barriers including technology access, digital literacy, and trust issues that require tailored solutions.

Ethical dimensions merit particular attention. Elgin and Elgin (2024) examined ethical implications of AI-driven clinical decision support systems, finding that healthcare professionals have significant concerns about resource allocation fairness, transparency of AI recommendations, and maintaining patient autonomy. Ramadan et al. (2024) found that 55% of Saudi nurses expressed ethical concerns, particularly around patient privacy. These findings underscore the need for robust ethical frameworks, transparent governance structures, and ongoing dialogue about appropriate AI use in nursing practice.

The issue of algorithmic bias deserves special consideration. Obermeyer et al. (2019) demonstrated that widely used healthcare algorithms can exhibit racial bias, with profound implications for equitable care delivery. While their study focused on U.S. populations, the principles apply universally: AI systems trained predominantly on Western populations may not perform equitably when applied to Saudi patients. Efforts to develop and validate AI systems using diverse Middle Eastern populations are essential to ensure fair performance across different demographic groups.

Workforce preparation emerges as a critical success factor. Multiple studies emphasize that nurses require not just technical training in AI tool use, but also development of AI literacy, critical evaluation skills, and understanding of ethical implications (Hassan & El-Ashry, 2024; Kwan, 2025). Asiri et al. (2025) found that variations in digital literacy and lack of specialized training remained significant challenges even in Saudi urban healthcare settings, suggesting even greater needs in rural areas where access to professional development is more limited.

Looking forward, several research priorities emerge. Rigorous evaluation of AI-enhanced telehealth nursing interventions specifically in Saudi rural contexts is needed, including effectiveness studies, cost-benefit analyses, implementation research, and qualitative investigations of patient and provider experiences. Comparative studies examining different implementation models would inform optimal program design. Long-term studies tracking sustainability, workforce retention, and population health outcomes will be essential to guide scaling decisions. As Perez et al. (2025) noted in their systematic review, despite growing evidence of AI and telemedicine benefits in rural communities, more real-world implementation studies are needed to validate findings and identify best practices for diverse contexts.

Recommendations

Based on the evidence synthesized in this review, several recommendations can guide the development and implementation of AI-enhanced telehealth nursing in rural Saudi Arabia:

For Policymakers and Healthcare System Leaders:

- Prioritize rural digital infrastructure development to ensure reliable connectivity sufficient for AI-powered telehealth applications, building on Vision 2030 digital transformation initiatives
- Establish clear regulatory frameworks for AI in healthcare that balance innovation with patient safety, including validation requirements, performance monitoring, and liability guidelines
- Create financial incentives and reimbursement mechanisms that support AI-enhanced telehealth nursing services in rural areas, recognizing the value of preventive and remote care
- Fund pilot programs and demonstration projects to test different AI-telehealth models in diverse rural Saudi contexts before large-scale rollout, learning from both successes and failures
- Invest in development of Arabic-language AI systems specifically designed for Saudi healthcare contexts, ensuring cultural appropriateness and linguistic accuracy

For Nursing Education and Professional Development:

- Integrate AI literacy and digital health competencies into nursing curricula at both undergraduate and graduate levels, preparing graduates for technology-enhanced practice environments
- Develop continuing education programs focused on AI-enhanced telehealth nursing for practicing nurses, with special attention to rural practitioners who may have limited access to professional development
- Create specialized certifications or advanced practice roles in telehealth nursing and health informatics, establishing clear career pathways and professional recognition
- Establish partnerships with international institutions to leverage global expertise in digital health education while ensuring cultural adaptation to Saudi contexts
- Ensure ethical frameworks and critical thinking about AI are central to education, not just technical skills, fostering nurses who can thoughtfully evaluate AI recommendations and maintain patient advocacy

For Healthcare Organizations and Telehealth Programs:

- Engage nurses as active stakeholders in AI system selection, implementation, and evaluation from the earliest planning stages, recognizing their frontline expertise and ensuring buy-in
- Implement comprehensive technical support systems to assist both nurses and patients in using AI-enhanced telehealth platforms, with culturally and linguistically appropriate resources
- Establish robust quality monitoring and feedback mechanisms to continuously evaluate AI system performance, identify errors or biases, and implement improvements
- Ensure cultural adaptation of AI systems and user interfaces to reflect Saudi values, language preferences, communication norms, and healthcare practices
- Develop protocols that clearly define when AI recommendations should be followed, questioned, or overridden based on nursing clinical judgment, preserving professional autonomy

For Research and Evaluation:

- Conduct rigorous evaluations of AI-enhanced telehealth nursing interventions in rural Saudi settings, measuring both clinical outcomes and implementation processes using appropriate methodologies

- Investigate patient and provider experiences, acceptance, trust, and satisfaction with AI-mediated care delivery through qualitative and mixed-methods research
- Examine health equity implications to ensure AI implementation reduces rather than exacerbates disparities between urban and rural populations, wealthy and poor communities, or different demographic groups
- Study long-term sustainability including workforce retention, cost-effectiveness, scalability, and population health impacts over multi-year timeframes
- Contribute to development of AI systems trained on diverse Middle Eastern populations to improve algorithmic fairness and performance across different demographic groups

Conclusion

The integration of artificial intelligence with telehealth nursing represents a transformative opportunity to expand healthcare access in rural and remote areas of Saudi Arabia. As this review demonstrates, AI technologies can enhance nursing capabilities across multiple dimensions from remote monitoring and diagnostic support to chronic disease management and patient education effectively amplifying the impact of limited nursing resources in underserved communities. The evidence base, drawn from 25 peer-reviewed studies with verified DOIs, provides a solid foundation for understanding both the potential and the challenges of implementation.

However, technology alone cannot solve complex healthcare access challenges. Successful implementation requires thoughtful attention to infrastructure development, cultural adaptation, regulatory frameworks, workforce preparation, and ethical considerations specific to the Saudi context. The goal should not be to replace human nursing care with technology, but rather to augment nursing expertise and extend its reach to populations who currently lack adequate access.

Saudi Arabia's Vision 2030 commitment to healthcare transformation, coupled with substantial investments in digital infrastructure and innovation, creates favorable conditions for AI-enhanced telehealth nursing development. Recent evidence demonstrates growing telehealth acceptance among Saudi adults (Sayed et al., 2025) and increasing recognition among nurses of AI's potential benefits (Ramadan et al., 2024), suggesting receptive stakeholders ready for thoughtful implementation.

Critical success factors include engaging nurses as active stakeholders in technology design and implementation (Hassan & El-Ashry, 2024), prioritizing patient-centered care that preserves the therapeutic relationship, maintaining rigorous oversight of AI system performance for safety and equity (Elgin & Elgin, 2024), and investing in comprehensive workforce development (Kwan, 2025). By addressing these factors while building on Saudi Arabia's existing telehealth infrastructure and digital health initiatives (Al Baalharith et al., 2022; Asiri et al., 2025), the Kingdom can establish a model for leveraging artificial intelligence to advance health equity and improve population health outcomes in rural and remote communities.

As AI capabilities continue to evolve, ongoing evaluation, adaptation, and ethical reflection will be essential. The future of rural healthcare in Saudi Arabia will likely involve increasing collaboration between nurses and AI systems, but the essential human elements of empathy, cultural sensitivity, ethical reasoning, and holistic patient advocacy will remain uniquely and irreplaceably human contributions. By thoughtfully integrating AI with these enduring nursing values, Saudi Arabia can expand healthcare access while preserving the human-centered care that is nursing's greatest strength.

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