

Chapter 10

Blockchain and AI in Rural Healthcare: Ensuring Secure and Smart Treatment


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ABSTRACT

The integration of blockchain, artificial intelligence (AI), and digital twin (DT) technologies is revolutionizing healthcare delivery, particularly in rural and underserved areas. This chapter explains how these technologies combined address some of the most significant issues such as secure handling of electronic health records (EHRs), privacy-preserving data sharing, real-time patient monitoring, and effective healthcare resource management. Blockchain offers decentralized, tamper-proof data management and enhances transparency across medical and pharma supply chains. AI allows predictive healthcare, treatment plans for individuals, and home-based monitoring through the Internet of Medical Things (IoMT), while DTs mimic healthcare systems and patient models to advance planning, diagnostics, and outcomes. The two technologies combined form a more inclusive, smart, and resilient health ecosystem that shatters infrastructure, access, and privacy barriers, allows for real-time decision making, and supports clinical precision among high-risk populations.

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1. INTRODUCTION: RURAL HEALTHCARE CHALLENGES AND THE ROLE OF EMERGING TECHNOLOGIES

Part of the foundation for restructuring rural healthcare systems is in the secure handling of electronic health records (EHRs) and protecting sensitive patient data. Patient records in the majority of rural settings are still stored manually or on scattered digital systems that can be lost, altered, or accessed unlawfully. This creates significant impediments to continuity of care, especially when patients are treated by multiple providers or travel to cities for specialty services. Blockchain technology offers a solution in that its decentralized architecture eliminates single points of failure and secures data with cryptographic hashing. By storing medical information in immutable ledgers and employing smart contracts for permissioned viewing, blockchain ensures that only authorized individuals—a patient's doctor or specialist, for instance—can view or modify EHRs (Bathula et al., 2024; Balasubramanyam et al., 2024). Not only does this reduce the likelihood of medical errors, but it also promotes trust in digital health services, an important factor in regions where digital expertise is limited and there is a strong suspicion of technology.

At the same time, performance and integrity of pharma and vaccine supply chains are essential to successful public health care in remote or underserved areas. These are most exposed to counterfeit drugs, largely due to ineffective regulation and long and complex supply chains. Blockchain supply chain management platforms solve this by recording every transaction from warehouse to factory and from point of care to shipment onto an open, tamper-evident ledger (Abbas et al., 2020; Antal et al., 2021; Di Francesco Maesa & Ricci, 2023). This will make drugs authentic, properly treated (e.g., kept at the right temperature), and where and when they are needed. This traceability is especially critical for temperature-sensitive vaccines such as the COVID-19 vaccines requiring uninterrupted cold chains to be effective (Antal et al., 2021). To be able to trace all doses back to their source also helps with product recall or side effects, enabling rapid response and accountability.

Additionally, **artificial intelligence (AI)** and **Internet of Things (IoT)** technologies are reshaping the delivery of healthcare through **remote patient monitoring systems**. In rural communities where medical professionals are scarce and clinics may be hours away, **smart wearable devices** can continuously track vital signs such as heart rate, blood pressure, oxygen saturation, and temperature (Sowunmi et al., 2024). These data are processed locally using **fog computing**, reducing latency and bandwidth consumption, and then securely transmitted via **private blockchain networks** to healthcare providers for real-time analysis (Schuler et al., 2023). Such systems enable **early detection of complications**, timely interventions, and personalized treatment adjustments without requiring patients to travel. This not only improves health outcomes but also alleviates the logistical and financial burden on both patients and health systems.

More generally, the health impacts of climate change are being felt more and more by rural communities, especially in areas like sub-Saharan Africa. Malnutrition, heat stress, water-borne illnesses, and respiratory ailments have all been associated with rising temperatures, altered precipitation patterns, and harsh weather. Rural communities are especially vulnerable because of their inadequate emergency response capabilities, lack of infrastructure, and reliance on climate-sensitive resources. Both technological innovation and strategic vision are necessary to meet these changing problems (Belchior et al., 2024).

This is where Digital Twin (DT) technology comes in to transform the process. By developing dynamic, real-time replicas of public health systems, DTs enable policymakers, researchers, and public health professionals to pilot various intervention tactics, predict outcomes, and evaluate resource requirements before rolling out programs in the field (Baucas et al., 2023; Sai & Vranken, 2024). For instance,

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