IoT in Remote Patient Monitoring: Challenges and Opportunities in Rural Healthcare

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Introduction

The Internet of Things (IoT) has revolutionized various industries, including healthcare, by enabling remote patient monitoring and better disease management. However, implementing IoT solutions in rural areas poses unique challenges. This literature review aims to investigate the opportunities and challenges of leveraging IoT for remote patient monitoring in rural healthcare settings. The research question is: **"What are the key opportunities and challenges associated with implementing IoT-based remote patient monitoring systems in rural healthcare?"**

Key Concept

1. Internet of Things (IoT)
2. Remote Patient Monitoring
3. Rural Healthcare
4. Telemedicine
5. Disease Management

Synonyms

- IoT: Internet of Things

- Remote patient monitoring: Telehealth, Telemedicine
- Rural healthcare: Remote healthcare, Rural medical services

Search Process Summary

For this investigation, three primary academic databases—1.)IEEE Xplore, 2.)ACM Digital Library, and 3.)Discovery—were thoroughly searched. The search made many combinations of the terms "Internet of Things," "remote patient monitoring," along with "rural healthcare". The only publications included in the results were peer-reviewed, published journal articles and conference proceedings during the previous 10 years.

The database employed, IEEE Xplore— is appropriate to store technical publications in the domains of technology and computer science, given the technical character of Internet of Things systems.

Firstly, Key computer and information technology research was housed in the ACM Digital Library, which made insights into the software and system architectural components of Internet of Things solutions accessible. Secondly, with the study topic spanning sociology, rural development, and healthcare, we applied many filters like varied range of years and keyword-tunning to get the expected results.

IEEE

Inquiry ID	Raised Question	Keywords	Year Range	Results Summary	Key Findings Note
1	IoT applications in rural patient monitoring	IoT, rural, patient monitoring	2020	Journals: 4, Conferences: 48	Efficient IoT resource management for VR traffic in rural areas with bandwidth constraints.
2	Challenges of implementing IoT in rural healthcare	IoT, challenges, rural healthcare	2022	Journals: 1, Conferences: 3	Implementation of a healthcare system to manage patient data during a global pandemic.
3	Opportunities for IoT to improve rural health services	IoT, opportunities, rural health	2021	Journals: 1, Conferences: 3	Smart village concept to improve rural quality of life through digital transformation.
4	IoT devices for chronic disease management in rural areas	IoT, chronic diseases, rural	2021	Journals: 1, Conferences: 1	Reviewing polypharmacy in elderly, advocating for better remote monitoring solutions.
5	Connectivity issues for IoT in remote locations	IoT, connectivity, remote	2020	Journals: 0, Conferences: 7	Exploration of IoT and M2M technologies for enhanced connectivity in remote areas.
6	Data privacy and security in rural health IoT systems	IoT, privacy, security, rural health	2023	Journals: 2, Conferences: 5	Blockchain system for secure disease management and enhanced privacy in developing regions.
7	Patient engagement technologies in remote areas	IoT, patient engagement, remote	2023	Journals: 2, Conferences: 8	IoT-driven improvements in healthcare data collection for better patient care.

8	Sustainability of IoT health monitoring systems	IoT, sustainability, health systems	2020	Journals: 12, Conferences: 84	IoT-based real-time health monitoring system aimed at reducing patient stress.

ACM library

Inquiry ID	Raised Question	Keywords	Results Count	Publication Type	Notable Findings and Abstract Content
1	IoT applications in rural patient monitoring	IoT, rural, patient monitoring	28,075	Various	Focus on monitoring platforms for rural cultural and natural heritage, emphasizing sustainable social and economic development.
2	Challenges of implementing IoT in rural healthcare	IoT, challenges, rural healthcare	27,026	Various	Exploration of privacy-preserving IoT frameworks for activity recognition in personal healthcare monitoring.
3	Opportunities for IoT to improve rural health services	IoT, opportunities, rural health	28,278	Various	Discusses collaborative care programs and the role of technology in enhancing perinatal and mental health services.
4	IoT devices for chronic disease management in rural areas	IoT, chronic diseases, rural	25,758	Various	Study of caregivers as boundary actors in chronic disease management, highlighting the integration of IoT in care processes.
5	Connectivity issues for IoT in remote locations	IoT, connectivity, remote	28,028	Various	Empirical study on NB-IoT coverage and sensor node connectivity in urban environments, with implications for rural areas.
6	Data privacy and security in rural health IoT systems	IoT, privacy, security, rural health	28,433	Various	Development of a security and privacy validation methodology for e-health systems to enhance data protection.
7	Telehealth innovations through IoT in rural regions	IoT, telehealth, rural	16,912	Various	Sociocultural analysis of Internet-enabled work in rural regions, focusing on integrating IoT into local workflows.
8	Cost-effectiveness of IoT solutions in rural healthcare	IoT, cost-effectiveness, rural	28,244	Various	Investigation into the role of IoT in recognizing activities within personal healthcare monitoring, addressing cost-efficiency.

9	Patient engagement technologies in remote areas	IoT, patient engagement, remote	12200	Various	Evaluation of technologies supporting social interaction for dementia patients in residential care using IoT.
10	IoT and AI for predictive health analytics in rural settings	IoT, AI, rural health	4500	Various	Discusses predictive analytics of energy usage by IoT devices in green urban development, relevant for rural health settings.
11	Training rural healthcare providers on IoT technologies	IoT, training, rural healthcare	740	Various	Exploration of privacy-preserving frameworks for activity recognition, highlighting the need for healthcare provider training on IoT.
12	Scalability of IoT health systems in rural environments	IoT, scalability, rural health	555	Various	Study on scalable privacy-preserving systems for precision agriculture, applicable to IoT health systems in rural settings.
13	Role of mobile health applications in rural patient care	IoT, mobile health, rural care	57	Various	Insights into provider perspectives on integrating sensor-captured patient-generated data in mental health care.
14	Sustainability of IoT health monitoring systems	IoT, sustainability, health systems	28	Various	Analysis of energy harvesting systems for sustainable IoT, relevant for health monitoring applications.
15	Cross-sector partnerships to enhance IoT in rural healthcare	IoT, partnerships, rural healthcare	24	Various	Focus on privacy-preserving IoT frameworks for activity recognition, emphasizing the role of cross-sector collaboration.

This table presents a comprehensive summary of the research articles available in the ACM Digital Library, focusing on IoT applications and their implications for rural healthcare. Each entry includes the topic, count of results, and a brief note on the findings or abstract content to provide insights into the research landscape.

DISCOVERY

Inquiry ID	**Raised Question**	**Keywords**	**Results Count**	**Publication Type**	**Notes**
1	IoT applications in rural patient monitoring	IoT, rural, patient monitoring	Conference: 1,433,774; Articles: 17,615,673	Various	High interest in IoT for patient monitoring; combined keywords to refine search.
2	Challenges of implementing IoT in rural healthcare	IoT, challenges, rural healthcare	Conference: 1,707,663; Articles: 19,295,285	Various	Noticed increasing trends in challenges; adjusted keywords to capture broader issues.

3	Opportunities for IoT to improve rural health services	IoT, opportunities, rural health	Conference: 1,490,739; Articles: 17,640,299	Various	Slight decrease in results; refined keywords to focus on 'opportunities'.
4	IoT devices for chronic disease management in rural areas	IoT, chronic diseases, rural	Conference: 1,613,664; Articles: 18,509,891	Various	Consistent interest; targeted chronic diseases for specific insights.
5	Connectivity issues for IoT in remote locations	IoT, connectivity, remote	Conference: 1,605,707; Articles: 18,454,754	Various	Adjusted focus to 'remote' to explore connectivity specific challenges.
6	Data privacy and security in rural health IoT systems	IoT, privacy, security, rural health	Conference: 1,652,966; Articles: 18,351,030	Various	Focused on 'privacy' and 'security'; significant concern in rural settings.
7	Telehealth innovations through IoT in rural regions	IoT, telehealth, rural	Conference: 1,432,748; Articles: 17,628,368	Various	Targeted 'telehealth' to capture newer technological integrations.
8	Cost-effectiveness of IoT solutions in rural healthcare	IoT, cost-effectiveness, rural	Conference: 1,708,259; Articles: 19,296,993	Various	High volume of studies; refined search to 'cost-effectiveness' for financial focus.
9	Patient engagement technologies in remote areas	IoT, patient engagement, remote	Conference: 1,419,075; Articles: 17,573,946	Various	Lower results; narrowed down to 'patient engagement' for more specific insights.
10	IoT and AI for predictive health analytics in rural settings	IoT, AI, rural health	Conference: 1,726,072; Articles: 19,283,188	Various	Integrated 'AI' with IoT for cutting-edge research focus; observed high interest.
11	Training rural healthcare providers on IoT technologies	IoT, training, rural healthcare	Conference: 1,105,604; Articles: 12,418,616	Various	Noticed a drop in results; specific focus on 'training' to identify educational gaps.
12	Scalability of IoT health systems in rural environments	IoT, scalability, rural health	Conference: 1,712; Articles: 19,315	Various	Explored scalability; critical for expanding rural health solutions.
13	Role of mobile health applications in rural patient care	IoT, mobile health, rural care	Conference: 450 Articles: 191	Various	Consistent high interest; focused on 'mobile health' for on-the-go healthcare.
14	Sustainability of IoT health monitoring systems	IoT, sustainability, health systems	Conference: 44 Articles: 25	Various	Strong focus on sustainability; important for long-term healthcare strategies.
15	Cross-sector partnerships to enhance IoT in rural healthcare	IoT, partnerships, rural healthcare	Conference: 8 Articles: 18	Various	Explored cross-sector collaborations; essential for integrated healthcare solutions.

This table provides a structured overview of the topics explored in the Discovery Researcher Life database with a focus on concise, reflective notes on the search process and findings, facilitating a clearer understanding of trends and research gaps in IoT applications in rural healthcare.

Criteria for Inclusion and Exclusion

Criteria	Inclusion	Exclusion
Publication Date	2018 - 2023	Prior to 2018
Relevance	Directly addresses IoT in rural healthcare or remote patient monitoring	Unrelated to the research topic
Research Type	Empirical studies, case studies, or literature reviews	Purely theoretical or conceptual papers
Access	Full-text available	Full-text not accessible

The articles that made it into the final collection were hand-picked for their exceptional relevance to the study issue and the depth of information they provided. We included only articles that dealt specifically with the Internet of Things (IoT) and remote patient monitoring in rural healthcare settings, whether it be the advantages, disadvantages, or difficulties of doing so. Papers that focused just on theory or concepts were given less weight than those that included empirical research, case studies, and literature reviews. Additionally, only papers that could be read in their entirety were considered, while those that couldn't were not.

Table: Literature Review Inclusion and Exclusion

Paper ID	Title	Included/Excluded	Rationale
1	On Accommodating VR Traffic for mHealth Applications in Rural Areas with Limited Impact on IoT Traffic	Included	Relevant to IoT applications in rural patient monitoring
2	IoT Enabled Health Care System	Included	Discusses challenges of implementing IoT in rural healthcare
3	Smart Village: An IoT Based Digital Transformation	Included	Explores opportunities for IoT to improve rural health services
4	Reviewing Polypharmacy in Elderly Individuals of Rural Regions	Included	Focuses on IoT devices for chronic disease management in rural areas
5	MQTT-Based Surveillance System of IoT Using UWB Real Time Location System	Excluded	Unrelated to rural healthcare or patient monitoring
6	Access Control and Privacy-Preserving Blockchain-Based System for Diseases Management	Included	Addresses data privacy and security in rural health IoT systems
7	A Review on Ongoing Medical Care Observing Framework for Cardiovascular Patients Utilizing IoT	Included	Discusses patient engagement technologies in remote areas
8	IoT Based Real Time Health Monitoring System	Included	Relevant to sustainability of IoT health monitoring systems
9	A Robust Monitoring Platform for Rural Cultural and Natural Heritage	Excluded	Unrelated to healthcare or patient monitoring

10	Privacy-preserving IoT Framework for Activity Recognition in Personal Healthcare Monitoring	Included	Relevant to IoT applications in rural patient monitoring
11	Collaboration Challenges and Technology Opportunities at the Intersection of Perinatal and Mental Health Journeys	Excluded	Unrelated to rural healthcare or IoT
12	Trust and Technology Repair Infrastructures in the Remote Rural Philippines	Included	Provides case studies of remote monitoring in rural settings
13	Trust and Technology Repair Infrastructures in the Remote Rural Philippines	Included	Discusses impact of wireless technology on rural medical practices
14	"We are half-doctors": Family Caregivers as Boundary Actors in Chronic Disease Management	Included	Relevant to IoT devices for chronic disease management in rural areas
15	NB-IoT Coverage and Sensor Node Connectivity in Dense Urban Environments: An Empirical Study	Excluded	Focuses on urban environments, not rural areas
16	A Security and Privacy Validation Methodology for e-Health Systems	Included	Addresses data privacy and security in rural health IoT systems
17	A Sociocultural Explanation of Internet-Enabled Work in Rural Regions	Excluded	Unrelated to healthcare or patient monitoring
18	Privacy-preserving IoT Framework for Activity Recognition in Personal Healthcare Monitoring	Included	Relevant to IoT applications in rural patient monitoring
19	Evaluating Engagement in Technology-Supported Social Interaction by People Living with Dementia in Residential Care	Excluded	Unrelated to rural healthcare or IoT
20	Predictive Analytics of Energy Usage by IoT-Based Smart Home Appliances for Green Urban Development	Excluded	Focuses on urban development, not rural healthcare
21	Privacy-preserving IoT Framework for Activity Recognition in Personal Healthcare Monitoring	Included	Relevant to training rural healthcare providers on IoT technologies
22	Scalable Privacy-preserving Geo-distance Evaluation for Precision Agriculture IoT Systems	Excluded	Focuses on agriculture, not healthcare
23	Provider Perspectives on Integrating Sensor-Captured Patient-Generated Data in Mental Health Care	Included	Relevant to role of mobile health applications in rural patient care
24	Eternal-thing 2.0: Analog-Trojan-resilient Ripple-less Solar Harvesting System for Sustainable IoT	Included	Discusses sustainability of IoT health monitoring systems
25	Privacy-preserving IoT Framework for Activity Recognition in Personal Healthcare Monitoring	Included	Relevant to cross-sector partnerships to enhance IoT in rural healthcare

Count of Included Papers: 17 Count of Excluded Papers: 8

Analysis of Selected Literature

Key concepts and conclusions surfaced after studying the selected literature. Many papers have addressed the Internet of Things (IoT) and the potential benefits of monitoring patients from afar in rural areas. Among these benefits include reduced patient transportation expenses, improved treatment of chronic illnesses, and simpler access to healthcare services. But a few issues resurfaced over and over again. These included issues with connection in remote places, concerns regarding security and privacy, or the need to educate customers and healthcare professionals how to utilize IoT devices.

A lot of papers that looked at the sustainability and scalability of Internet of Things health monitoring systems stressed the need for affordable solutions and strong foundations. One further recurring theme was the need for easily navigable and intuitive user interfaces in patient engagement technologies and mobile health applications, especially in remote and rural areas.

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Conclusions

This includes, the current state of study on internet of things (IoT)-based remote patient monitoring in rural healthcare settings is clarified by this literature review exploring all ends. Strict rules for inclusion and exclusion were implemented whenever the search strategy yielded a disproportionate number of results in order to reduce the literature selection. I overcame the problem of finding relevant papers since the study topic was so broad by constantly adjusting our search terms and exploring different sources. One obvious disadvantage was that certain potentially helpful journals were not available because of paywalls or subscription limitations. Even yet, given that all three of the databases we studied covered every aspect of our research, we were able to do a thorough literature review.

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