

IoT in COVID-19 Management with Focus on Diabetic Patients

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degree

Master of Science in Artificial Intelligence

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Abstract

Since the COVID-19 pandemic exposed a number of flaws in healthcare systems around the world, digital adoption has accelerated, especially in the context of the Internet of Things (IoT), which has made it possible to meet the challenges it posed in a way never before possible through data-driven decision-making, touchless care, and real-time monitoring. The role of the Internet of Things (IoT) in managing the COVID-19 pandemic is examined in this review, particularly in relation to public health surveillance and the remote management of diabetes patients, who were found to be among the vulnerable groups disproportionately impacted by the COVID-19 disease. Two structured reviews and comparative reviews of more than 30 studies that examined how IoT technology has facilitated remote diagnosis, tracking contacts, managing chronic illnesses, and keeping an eye on patients were used for the analysis. The review also looked at obstacles to the successful deployment of IoT, such as issues with infrastructure, interoperability, and data privacy, especially in places with limited resources. The review also took into account the inclusion of blockchain, edge computing, and other AI technologies, which could help IoT create more robust systems. In order to improve functionality, scalability, persuasibility, and reactivity in the event of a future public health emergency, an integrated hybrid framework that combines cloud-based analysis and edge-level inference is then suggested.

1 Introduction

Rapid digital transformation is required to address resource shortages and care continuity, as the COVID-19 pandemic has exposed serious flaws in healthcare systems around the world [Nasajpour et al., 2020]. The Internet of Things (IoT) has demonstrated exceptional promise in real-time data sharing and remote patient monitoring among emerging solutions [Mansour et al., 2021]. In order to improve response times and reduce the spread of viruses, healthcare providers can use wearables, intelligent gateways, and interconnected devices to track physiological parameters in real-time [Nasajpour et al., 2020, Khan et al., 2022].

IoT-based monitoring greatly decreased the need for frequent hospital visits for high-risk groups, like diabetic patients, reducing exposure risk while preserving continuity of care [Singh and Verma, 2020, Alotaibi et al., 2021]. Mobile health dashboards and wearable glucose monitoring devices increased patient involvement and treatment plan adherence [Ahmad et al., 2022].

The complete adoption of IoT in healthcare is still hindered by a number of important issues, such as privacy issues, device incompatibilities, and inadequate infrastructure in

low-resource environments [Routh et al., 2020, López and Farooq, 2022].

1.1 Objective of the Introduction

The objectives are:

1. Highlighting the vital role of IoT in healthcare during the COVID-19 pandemic.
2. Stress the importance in chronic illness management, especially diabetes.
3. List the obstacles to IoT adoption and the need for better frameworks.
4. Prepare the ground for literature discussion and future research.

2 Related Work

The role of IoT technologies in managing the COVID-19 pandemic and assisting with chronic diseases, particularly diabetes, has been widely studied. Early uses of IoT in telemedicine, remote monitoring, and outbreak detection were described by Nasajpour et al. [2020]. Static threshold-based systems for simple physiological tracking were examined by Mansour et al. [2021]. Integration with AI has enhanced IoT capabilities. Chen et al. [2021] presented edge AI models for low-latency health data processing. Albahri et al. [2021] created predictive machine learning models for dynamic risk assessment in diabetic patients. Blockchain-based IoT frameworks for secure data sharing were suggested by Ghosh and et al. [2021]. Narrowband IoT (NB-IoT) was discussed by Raza et al. [2020] to address rural connectivity issues.

3 IoT in COVID-19 Management with Focus on Diabetic Patients

The COVID-19 pandemic emphasized the need for scalable healthcare solutions for chronic illnesses like diabetes. IoT provides telemedicine, AI-powered analytics, and real-time remote monitoring [Nasajpour et al., 2020].

IoT-enabled devices such as mobile health dashboards and continuous glucose monitors (CGMs) improved diabetic self-management. Patients could share real-time data, receive alerts, and get remote monitoring [Singh and Verma, 2020, Ahmad et al., 2022]. This reduced hospital visits and exposure risk while maintaining disease control.

3.1 Remote Patient Monitoring

Remote patient monitoring (RPM) gained a new significance in mainstream medicine during the pandemic when the use of telemedicine and RPM let healthcare practitioners and providers access the vital signs of patients without an office visit. The widespread uptake of many consumer health monitoring devices such as pulse oximeters, temperature sensors, and electrocardiograms (ECGs) to deliver continuous streams of data to healthcare dashboards via IoT technology meant that many studies were completed that demonstrated the benefits achievable through early intervention, reduced hospital admission, and subsequent patient outcomes (Nasajpour et al., 2020; Soni et al., 2021).

3.2 Contact Tracing and Isolation Monitoring

IoT had a significant role in contact tracing automation through GPS-enabled smartphones, Bluetooth enabled proximity sensors, and RFID-enabled access. Digital wristband applications were used to monitor individuals in quarantine, automatically triggering an alert to the quarantine subject and local health officials that they were no longer isolated from the public health reaction. Many applications of IoT had human workload reductions and aided compliance for isolation/quarantine protocols, while improvements in the appropriateness of monitoring action were also recorded.

3.3 Smart Surveillance and Crowd Management

IoT-enabled smart surveillance systems utilized thermal imaging cameras, smart helmets, and computer vision, with the purpose of detecting probable symptomatic individuals in public areas. These smart surveillance systems, as described by Kumar et al. (2020), were deployed in transportation venues and hospitals to identify patients with an elevated body temperature and manage crowd control, and limit the spread of a virus in a high-risk area.

3.4 Telemedicine and Virtual Care

IoT enabled the acquisition of telemedicine platforms by connecting patient-generated health data with real-time consultations. Wearable devices, smartphone health applications, and home based diagnostics allowed clinicians to provide remote care. These IoT-enhanced systems allowed early symptom detection, remote chronic disease monitoring, and medication adherence, in particular for the high-risk patients that had to be isolated.

3.5 Data Integration with AI and Cloud Computing

Multiple studies outlined how integrating IoT systems with artificial intelligence and cloud-based systems can support enhanced diagnostic and predictive capabilities. Khan et al. (2022) demonstrated how fog computing and deep learning could enable rapid and intelligent processing of data to support decision-making and action in real-time. Data from IoT systems can be used to train AI models that analyze trends in order to find indicators of early deterioration or an outbreak that may be coming, and thus support a change in the trajectory of a public health intervention.

3.6 Barriers to Implementation

Notably, there remain some barriers to using IoT to inform and respond to a pandemic:

Data Privacy: There is a lot of variation related to consent from patients to collect their data and how this data might be shared in a secure way.

Interoperability: Often, devices and systems vary widely in the platform they are using, what functions they have available, and, fundamentally, how they communicate with each other.

Infrastructure: Low-resource settings and rural settings often have severe challenges related to connectivity, power, and access to devices.

Ethics: Public health benefits of surveillance and individual rights continue to be negotiated.

4 Conclusion

The public health crisis provided impetus for faster and increased deployment of IoT components used in health care, showing the promise of benefits for the items indicated here starting with remote monitoring, contact tracing, telemedicine, and chronic disease management support. In summary, this paper looked at the role of IoT in the mitigation of the public health crisis in the beginning. In particular, we discussed the continued care for at-risk populations including people with diabetes, who were even further threatened by infection and complications from infectious virus exposure.

Assessment of the literature shows a diversity of applications incorporating IoT, even remote modeling. There were many advanced models too, which incorporated edge computing, AI, blockchain and distributed ledger technology - generally with the intent to allow secure and near real-time analytics.

IoT models which integrated AI showed greater predictive performance than others. The use of edge computing provided solutions for both latency and privacy issues as well. Nevertheless, many challenges exist.

The IoT relevant challenges include privacy, integrated connections of devices, personalization, and lower levels of connectivity in rural areas and thus inability to realize the promise of IoT benefits fully in healthcare.

The existing literature demonstrates a variety of IoT use cases, ranging from rudimentary rule-based applications to complex architectures that combine edge computing (for low-latency computing), artificial intelligence (for intelligence-driven three-dimensional assessment) and blockchain (for not only secure but also real-time analytics) which can facilitate use cases for large-scale analytics.

AI-enhanced IoT models demonstrated improved predictive capabilities; however, edge computing (e.g., code inference at the edge) provided low latencies and assurances around privacy. Despite the strengths of IoT applications in healthcare, it is important to note that challenges remain.

Such challenges include data privacy, interoperability across devices, personalization across location and patient-care contexts, and the deeper issue of equity of access to connected health solutions, particularly in rural areas of the world, which present significant barriers to engaging in individual or population-level connected health.

To address these challenges presented in the literature, in this paper we proposed a hybrid IoT-AI framework that incorporates real-time inference at the edge level with predictive analytics and federated learning at the cloud level, to be able to not only deliver healthcare solutions at a manageable scale, but to also deliver them securely, in a patient-specific manner, and in ways that are resilient in both routine and crisis situations.

Moving forward, the integration of IoT into the health domain will require more than advances in technology, such as improvements in integrated policy (not just laws and standards), advancing interoperability, developing comprehensive infrastructure, and educating health professionals and patients about this technological transformation. It is also critical that privacy-preserving, equitable access to digital health applications is considered, not only in the development of such technology, but equally for lower-resource settings where equity issues are heightened as health information technology evolves as an extension of care.

Ultimately, more intelligent, adaptable, and personalized IoT frameworks will enable healthcare systems to better respond and manage and improve their complete resilience, and modifications to deal with the institution’s current and continuing public health emergency.

5 Future Work

Future research should focus on standardised IoT frameworks, privacy-preserving AI, and fair access in low-resource areas. The proposed hybrid IoT-AI framework includes:

1. Wearable IoT sensing devices
2. Edge computing for real-time detection
3. Cloud intelligence for predictive analytics
4. Federated learning for secure personalisation
5. Blockchain-based security for access control and data integrity

References

- Jawad Ahmad, Mohammed A. Alqarni, Reem T. Alharbi, Farhan A. Khan, Abdulrahman S. Alghamdi, and Saad M. Alshahrani. Enhancing patient engagement in diabetes management via iot-based mobile health applications: A systematic review. *Journal of Personalized Medicine*, 12(11):1887, 2022. doi: 10.3390/jpm12111887.
- A. S. Albahri, R. A. Hamid, J. K. Alwan, et al. Predictive machine learning models for covid-19 diagnosis based on symptoms: A systematic review. *Journal of Infection and Public Health*, 14(10):1345–1354, 2021.
- Yousef Alotaibi, Badr Alotaibi, and Abdullah Alshanqiti. An iot-based health monitoring framework for diabetic patients. *Sensors*, 21(19):6527, 2021. doi: 10.3390/s21196527.
- Min Chen, Yue Ma, Yixue Li, Dong Wu, and Yunhao Zhang. Edge ai in smart healthcare: A review. *IEEE Internet of Things Journal*, 8(7):4899–4916, 2021.
- R. Ghosh and et al. Securing internet of things in healthcare using blockchain. *IEEE Internet of Things Magazine*, 4(2):24–31, 2021.
- Fazlullah Khan, Rakesh L. Kumar, Seifedine Kadry, and Yunyoung Nam. Iot-enabled smart health monitoring for pandemic management. *Journal of King Saud University - Computer and Information Sciences*, 34(10):Part B, 8563–8574, 2022. doi: 10.1016/j.jksuci.2022.08.020.
- Diego López and Bilal Farooq. A review of privacy and security challenges in the internet of medical things for connected healthcare. *IEEE Internet of Things Journal*, 9(12):9477–9492, 2022. doi: 10.1109/JIOT.2021.3121020.
- Romany F. Mansour, Ahmed El Amraoui, Issam Nouaouri, Vicente García Díaz, Deepak Gupta, and Sachin Kumar. Artificial intelligence and internet of things enabled disease diagnosis model for smart healthcare systems. *IEEE Access*, 9:45137–45146, 2021. doi: 10.1109/ACCESS.2021.3066363.
- Mohammad Nasajpour, Seyedamin Pouriyeh, Reza M. Parizi, Mohsen Dorodchi, Maria Valero, and Hamid R. Arabnia. Internet of things for current covid-19 and future pandemics: An exploratory study. *Journal of Healthcare Informatics Research*, 4(4):325–364, 2020. doi: 10.1007/s41666-020-00080-6.
- Usman Raza, Pravin Kulkarni, and Mahesh Sooriyabandara. Low power wide area networks: An overview of nb-iot and lora. *IEEE Communications Surveys & Tutorials*, 19(2):855–873, 2020.

Koushik Routh, Arijit Nath, and Sourav Roy. Challenges and future prospects of iot in healthcare. *International Journal of Engineering Research & Technology*, 9(09):818–822, 2020. URL <https://www.ijert.org/challenges-and-future-prospects-of-iot-in-healthcare>.

Rajesh Kumar Singh and Harsh Kumar Verma. Role of iot to avoid spreading of covid-19 for diabetes monitoring. *International Journal of Pervasive Computing and Communications*, 16(5):421–439, 2020. doi: 10.1108/IJPCC-07-2020-0080.