



# **Research Methodology in Computer Science**

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## **The Role of IoT in COVID-19**

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## Introduction

The Internet of Things (IoT) has rapidly evolved, significantly impacting various fields, including smart urban systems and medical advancements. When the COVID-19 pandemic emerged in late 2019, IoT technologies became essential in addressing new challenges. This research examines the role of IoT during the pandemic, focusing on its contributions to enhancing healthcare responses, implementing prevention strategies, and ensuring the resilience of healthcare systems during emergencies.

The widespread adoption of IoT during the pandemic also highlighted several critical challenges, including data security concerns, integration issues with existing systems, and privacy protection risks. Through case studies and practical implementations, this analysis demonstrates how IoT technologies played a fundamental role in crisis management. Wearable patient health monitors and smart sensor systems for social distancing enforcement exemplify IoT's effectiveness in managing health emergencies.

## **Research papers**

### **First Research Paper "The role of IoT in COVID -19"**

The paper evaluates how cloud and fog computing technologies support IoT systems in enabling rapid disease identification, virus transmission forecasting, and efficient healthcare resource distribution. It examines IoT applications during the COVID-19 pandemic through international case studies involving smart sensors, such as thermal scanners and wearable devices. These technologies facilitate the early detection of suspected cases and enable the remote monitoring of vital signs for isolated patients, ultimately improving hospital operational efficiency.

Fog computing enhances real-time data processing by distributing analysis across multiple network endpoints, reducing data travel time compared to cloud-based systems. However, integrating IoT into healthcare raises data privacy concerns, necessitating the use of advanced encryption techniques to ensure the security of medical operations.

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| <b>Title</b>               | <b>The Role of IoT in COVID-19</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Year of Publication</b> | 2021                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Authors</b>             | Nehal A.Mansour, Ahmed I. Saleh, Asmaa H. Rabie, and Hesham A.Ali                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Objectives</b>          | <ul style="list-style-type: none"> <li>• The study evaluates the impact of cloud and fog computing systems on IoT in enabling rapid infection detection, virus transmission forecasting, and the management of medical supplies during the pandemic.</li> <li>• The research examines the contributions of smart healthcare systems to pandemic response, including contact monitoring, enforcement of social distancing measures, and remote medical care delivery, while also identifying data protection and privacy risks.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Methodology</b>         | This research analyzes scientific literature and studies on Internet of Things (IoT) technology, fog computing, and cloud computing, focusing on their healthcare applications during crises, particularly the COVID-19 pandemic. Using analytical and inductive research methods, the study evaluates international case studies demonstrating the use of IoT systems in pandemic response, including digital contact-tracing applications and wearable devices for monitoring the vital signs of infected individuals.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Results</b>             | <ul style="list-style-type: none"> <li>• Smart sensors, such as electronic bracelets and thermal scanners, enable the rapid identification of suspected infections, allowing for immediate isolation to prevent further disease spread.</li> <li>• Remote monitoring of respiratory rate and oxygen levels in home-quarantined patients helps hospitals optimize resource allocation and improve efficiency.</li> <li>• Hospitals can process critical data on-site instead of relying solely on cloud systems, enabling faster responses to urgent information while minimizing transmission delays.</li> <li>• The use of connected medical devices poses a threat to medical data privacy, requiring healthcare organizations to implement advanced encryption systems for protection.</li> <li>• The integration of IoT technologies faces delays in several countries due to compatibility issues with existing healthcare infrastructure, hindering seamless adaptation to modern healthcare solutions.</li> </ul> |

## Second Research Paper “IoT technology during and beyond COVID-19”

The research applies the Technology Readiness Level (TRL) framework to assess IoT solutions by evaluating their deployment timelines, public reception, and privacy-related challenges. The study confirms that IoT monitoring systems, when integrated with AI and blockchain technology, can reduce viral spread rates by 30% in specific locations. However, it also highlights ongoing limitations that hinder their widespread adoption.

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| <b>Title</b>               | IOT technologies during and beyond COVID-19: A comprehensive review                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Year of Publication</b> | 2021                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Authors</b>             | Mohamed Yousif, Chaminda Hewage, Liqaa Nawaf                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Objectives</b>          | <ul style="list-style-type: none"><li>• Examine the social and economic impacts of IoT implementation during the pandemic, focusing on telehealth adoption and transportation system optimization.</li><li>• In the post-COVID-19 era, IoT solutions will encounter both opportunities and challenges, with artificial intelligence and blockchain technology driving next-generation innovations.</li><li>• Categorize IoT technology solutions using the Technology Readiness Level (TRL) framework, considering their estimated timeline for societal acceptance and projected social impact in a comprehensive manner.</li></ul> |

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| <b>Methodology</b> | <p>The research conducted a systematic review of published studies and literature on Internet of Things (IoT) implementations during COVID-19, focusing on three key sectors: healthcare, contact tracing, and transportation. A combination of quantitative metrics and qualitative indicators was analyzed to assess the socioeconomic impact of these technologies, particularly in reducing medical costs and improving healthcare system reliability.</p> <p>The study evaluated IoT technologies based on their Technology Readiness Level (TRL), implementation timeline, and socioeconomic implications. Additionally, it identified privacy and security risks, as well as emerging tools designed to support the broader adoption of integrated IoT solutions.</p>                                                                       |
| <b>Results</b>     | <ul style="list-style-type: none"> <li>• The Internet of Things (IoT) system provides important capabilities for remote patient tracking while also relieving hospital patient populations through mobile vital signs recording technology.</li> <li>• Medical diagnosis receives enhancement through sensor-based data collection.</li> <li>• The combination of smartphone applications which use GPS and Bluetooth technology works to detect more accurate cases of infection.</li> <li>• The implementation of monitoring systems creates areas that decrease viral spread by 30% effectively.</li> <li>• Smart programs should be implemented for vehicle and public movement control to minimize congestion.</li> <li>• A 20% decrease in operating expenses exists in several cities through optimized fuel consumption routes.</li> </ul> |

### Third Research Paper “Impact of IoT devices in E-Health”

A systematic literature review explored how Internet of Things (IoT) technologies addressed medical challenges posed by COVID-19 variants, with a particular focus on the 2019 outbreak in Wuhan, China, and the 2020 UK variant. The research employed mixed-method approaches to evaluate IoT applications, including wearable sensors and monitoring systems that tracked patients' vital signs (such as respiratory rate and oxygen levels), monitored their movements using GPS and Bluetooth, and optimized healthcare resource allocation.

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| <b>Title</b>               | Impact of IoT devices in E-Health: A Review on IoT in the context of COVID-19 and its variants                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Year of Publication</b> | 2021                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Authors</b>             | Fatima Zahra Fagroud, Hicham Toumi b, El Habib Ben Lahmar, Mohamed Amine Talhaoui, Khadija Achtaich, Sanaa El Filali                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Objectives</b>          | <ul style="list-style-type: none"><li>• Research analyzes how Internet of Things (IoT) technologies help resolve medical issues created by COVID-19 and its evolutionary variants.</li><li>• The assessment focuses on how IoT devices minimize virus spread through their implementation of remote health tracking systems and contact tracing technology.</li><li>• The implementation of IoT technology produces economic advantages and health improvements by minimizing healthcare service costs and delivering better patient results.</li><li>• Healthcare organizations need to understand both the benefits and limitations that exist when implementing IoT systems to react to upcoming pandemics.</li></ul> |

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| <p><b>Methodology</b></p> | <p>This study used a systematic literature review to examine the Internet of Things (IoT) applications within healthcare sector treatment of COVID-19 while concentrating on the original Chinese outbreak in Wuhan during December 2019 as well as emerging variant strains including the December 2020 UK mutation. The research methodology combined both quantitative along with qualitative data regarding how IoT devices (including sensors and wearables) monitor patient vital signs and track movements and control medical resource distribution. These technologies demonstrated their reduction capabilities of infection transmission through data analysis which showed better healthcare system efficiency and lower hospitalization numbers.</p>                                                                                                                                                                              |
| <p><b>Results</b></p>     | <ul style="list-style-type: none"> <li>• The use of remote health monitoring services decreases hospital trips which helps minimize both hospital visits and infection risks.</li> <li>• Tracing infected people through GPS and Bluetooth technology helps to isolate potential cases in a prompt manner.</li> <li>• Healthcare providers can achieve better treatment results by using real-time monitoring of vital signs that include respiratory rate together with oxygen levels.</li> <li>• Healthcare organizations can save up to 25% of expenses in certain areas because they lower severe infections as well as reduce hospital stays.</li> <li>• The research results confirmed that hybrid Internet of Things systems with AI support must be developed for higher data accuracy evaluation.</li> <li>• Regulatory policies need development to guarantee information security as well as patient privacy protection.</li> </ul> |

#### Fourth Research Paper “Role of IoT to avoid spreading of COVID-19”

This research examines how Internet of Things (IoT) technologies support the fight against the COVID-19 pandemic through an analysis of academic studies and practical implementations. It evaluates existing health monitoring solutions, including questionnaires and mobile applications, demonstrating how IoT systems enhance epidemic control by tracking vital signs through electronic bracelets and analyzing collective movements using Bluetooth, GPS data, and connected devices. These tools enable early symptom detection, hazard area identification, and virus spread forecasting, allowing medical teams to implement timely interventions for case isolation.

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|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Title</b>               | <b>Role of IoT to avoid spreading of COVID-19</b>                                                                                                                                                                                                                                                                     |
| <b>Year of Publication</b> | 2020                                                                                                                                                                                                                                                                                                                  |
| <b>Authors</b>             | Krishna Kumar, Narendra Kumar, Rachna Shah                                                                                                                                                                                                                                                                            |
| <b>Objectives</b>          | <ul style="list-style-type: none"><li>• Scientists examined the uses of surveillance technologies to fight the COVID-19 pandemic through examination of academic papers.</li><li>• The author creates an Internet of Things architecture to reduce virus spread by implementing smart surveillance systems.</li></ul> |
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| <p><b>Methodology</b></p> | <p>The study explored Internet of Things (IoT) applications in epidemic control by examining both scientific literature and real-world experiences related to COVID-19. It assessed existing questionnaire-based and mobile application-based health monitoring technologies through prior research, demonstrating how IoT systems can enhance their effectiveness through real-time vital sign tracking and collective movement analysis.</p>                              |
| <p><b>Results</b></p>     | <ul style="list-style-type: none"> <li>• Electronic bracelets among other IoT devices help healthcare providers monitor patients' vital signs while detecting foreign symptoms at an early stage.</li> <li>• Smart devices equip with Bluetooth technology and GPS function to detect at-risk areas for quick case isolation.</li> <li>• The method targets better analysis of virus path prediction through data processing from millions of connected devices.</li> </ul> |

## **Fifth Research Paper “Impact of COVID-19 on IoT adoption in healthcare, Smart home, Smart building, Smart cities, Transportation and Industrial IoT”**

This research examines how the COVID-19 pandemic accelerated the adoption of Internet of Things (IoT) technologies across healthcare services, smart homes, buildings, cities, transportation systems, and industrial production. It analyzes IoT projects that gained momentum during the pandemic by reviewing existing literature and consulting reports from McKinsey and Gartner.

One category of IoT initiatives includes telehealth systems and smart transportation solutions, such as contactless e-ticketing and automated sanitization. Another category involves IoT-enabled traffic control for lockdown management and supply chain optimization tools. Additionally, predictive maintenance systems in industries played a critical role in preventing production halts. The deployment of remote sensors to monitor industrial processes emerged as a key innovation, enabling efficient operations with minimal human intervention.

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|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Title</b>               | Impact of COVID-19 on IoT Adoption in Healthcare, Smart Homes, Smart Buildings, Smart Cities, Transportation and Industrial IoT                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Year of Publication</b> | 2021                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Authors</b>             | Umair, Muhammad; Cheema, Muhammad Aamir; Cheema, Omer; Li, Huan; Lu, Hua                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Objectives</b>          | <ul style="list-style-type: none"><li>• A thorough analysis should evaluate how COVID-19 affects the adoption process of Internet of Things (IoT) technology adoption across healthcare, smart homes, smart buildings, smart cities, transportation, and industrial IoT sectors.</li><li>• So examine major IoT projects that emerged during pandemic conditions inside each market segment.</li><li>• Research initiatives that expedite IoT implementation in current systems should be explored.</li></ul> |

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| <p><b>Methodology</b></p> | <p>The research relied on an extensive review of IoT application literature from both before and after COVID-19, supplemented by insights from McKinsey and Gartner reports on the pandemic's technological impact. The analysis focused on assessing each sector individually to identify effective IoT initiatives, such as telehealth systems and smart transportation solutions, and their role in accelerating innovation during the pandemic.</p>                                                                                                                               |
| <p><b>Results</b></p>     | <ul style="list-style-type: none"> <li>• The reduction of human contact relies on smart transportation solutions which have e-ticketing and automated vehicle sanitization features.</li> <li>• Lockdown management would benefit from IoT systems which perform traffic control and supply chain optimization.</li> <li>• Industrial facilities can prevent unexpected stopped production through predictive maintenance systems which operate machines automatically.</li> <li>• Companies that use remote sensors can now achieve better industrial process monitoring.</li> </ul> |

## Sixth Research Paper “The role of Internet of Things to control the outbreak of COVID-19 pandemic”

The proposed system features an integrated IoT and cloud-based infrastructure composed of four interconnected elements designed to enhance pandemic healthcare management. A variety of IoT devices, such as smartwatches and vital sign monitors, automatically collect real-time patient data, including temperature and respiratory rate measurements. This data is stored in both health center databases and cloud warehouses, where five machine learning models—utilizing random forest and support vector machines—predict COVID-19 severity levels.

Hospital professionals access COVID-19 treatment analytics through a centralized platform that provides immediate data availability for quick decision-making. By enabling remote patient monitoring, the system reduces patient exposure risks while automating medical care within healthcare facilities. Additionally, it optimizes resource management through urgent care prioritization and automates data processing, thereby reducing healthcare staff workloads and improving time efficiency.

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|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Title</b>               | The Role of Internet of Things to Control the Outbreak of COVID-19 Pandemic                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Year of Publication</b> | 2021                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Authors</b>             | Aniello Castiglione, Muhammad Umer, Saima Sadiq, Mohammad S Obaidat, Pandi Vijayakumar                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Objectives</b>          | <ul style="list-style-type: none"><li>• The proposed system includes four interconnected sections that start by collecting data before machine learning analysis precedes direct transfer to medical personnel for treatment.</li><li>• Examining how machine learning models particularly random forest perform in estimating the COVID-19 severity through IoT-generated data.</li><li>• Healthcare management systems become enhanced through real-time patient observation and decreased need for direct worker involvement.</li></ul> |

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| <p><b>Methodology</b></p> | <p>The research adopted an Internet of Things (IoT) and cloud-based technical framework which involves four procedure steps starting with the collection of real-time patient data from IoT devices including smart watches and vital signs measuring devices (respiratory rate, temperature, etc.). The Health center or central quarantine with IoT devices serves as a data storage point by receiving information from patients. Five machine learning models including random forest and automated support vector modeling run analyses of the data inside the cloud warehouse to predict infection severity levels. A fourth part of this system uses a unified platform for health professionals to access analytical results which enables them to make instant treatment choices.</p> |
| <p><b>Results</b></p>     | <ul style="list-style-type: none"> <li>• The IoT devices operated autonomously to acquire health measurements consisting of temperature and respiratory rates continuously from patients.</li> <li>• The implemented framework allowed healthcare providers to monitor patients remotely thus lowering the potential exposure risks in medical centers.</li> <li>• The system functioned efficiently toward resource distribution through its ability to detect urgent medical situations first.</li> <li>• The system lowered healthcare worker workload through automation that managed data collection together with analysis.</li> </ul>                                                                                                                                                   |

## **Strengths and weaknesses of research papers**

### **First Research Paper**

#### **Strengths:**

- The paper effectively demonstrates how fog and cloud computing technologies process data in real time, with a focused analysis of these specific technologies.
- The inclusion of international IoT examples, particularly wearables, enhances credibility and strengthens performance insights.
- The discussion on data security challenges provides a strong foundation for the necessity of developing encryption systems.

#### **Weaknesses:**

- The paper primarily examines the immediate impact of the pandemic on IoT but does not explore future adaptations for IoT systems.
- The research lacks specific solutions for integrating IoT systems with existing infrastructure components.

### **Second Research Paper**

#### **Strengths :**

- The study examined different sectors such as healthcare, transportation and contact tracing which created a complete assessment framework.
- The examination presented fiscal and societal effects which demonstrated a twenty percent cost reduction point.

#### **Weaknesses :**

- A broad-sector evaluation in this study resulted in a basic understanding of particular fields including transportation systems.
- No assessment exists in the report regarding the international divide between IoT adoption between economies with different levels of development.

### Third Research Paper

#### **Strengths :**

- The research analyzes healthcare specifically at a detailed level through the lens of cost reduction at 25%, which provides improved analytical insight.
- The application of remote vital signs monitoring served to demonstrate specific IoT advantages.
- The author developed visionary recommendations that involved AI-powered hybrid systems to push the boundaries of future technological development.

#### **Weaknesses :**

- The initiative exclusively concentrates on healthcare instead of expanding to encompass additional relevant sectors such as smart cities.
- The article ignored addressing privacy concerns in detail even though it labeled privacy issues as crucial concerns.

### Fourth Research Paper

#### **Strengths**

- The research presented an integrated IoT technical framework that enabled direct practical implementation against the pandemic.
- The article examined Bluetooth and GPS technologies as contact tracing methods while connecting scientific concepts with actual practice applications.

#### **Weaknesses**

- The proposed solutions lacked both practical tests in real-world conditions as well as supporting empirical evidence.
- The approach failed to discuss necessary logistical framework or economic implications of the theoretical recommendations.

## **Fifth Research Paper**

### **Strengths**

- The analysis benefitted from supporting data obtained from McKinsey consulting reports which enhanced its credibility.
- The report discussed two specific initiatives which combined contactless transportation methods with predictive testing programs for system maintenance.

### **Weaknesses**

- The adoption of IoT technology faces cultural barriers within certain communities which are not addressed.

## **Sixth Research Paper**

### **Strengths**

- The authors implemented an integrated healthcare system which united IoT, cloud technology as well as machine learning models to achieve successful technology-healthcare integration.
- Smart watches and vital signs monitors acting as IoT devices provided real-time data monitoring by measuring accurate continuous patient information.
- The Random Forest model achieved 95% precision for disease severity prediction thus enabling healthcare staff to make proper treatment decisions.

### **Weaknesses**

- The investigation depended solely on theoretical information and restricted data since there was no practical usage of the system to verify result stability.
- The analysis failed to evaluate the danger hackers pose to medical records transmitted through connected devices despite remaining a pressing issue in IoT systems.

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