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Role of IoT during Covid-19 Crisis: Adoptions, Challenges and Reflections on the Post-Pandemic World

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Abstract:
The newly discovered coronavirus also known as (COVID-19), according to the World Health Organization (WHO), is a worldwide epidemic, and it has altered people's way of life in general. The Internet of Things also known as (IoT) management and structure have also been impacted, along with other significant areas of the global economy and industry. This study provides a brief analysis of how a serious pandemic, like COVID-19, would affect the IoT sector. It looks at how the Internet of Things and related sensor technologies have helped to stop the spread of different infections and track their movements and understand trends of their spread. The challenges of deploying sensor hardware in the face of a pandemic that is spreading swiftly have been investigated in this review study. A worldwide pandemic's impacts on the development of IoT architectures and administration have also been discussed, which has led to predictions about how future IoT deployments will probably turn out. In general, this article gives readers a glimpse into how sensor-based E-health is progressing in its application to the control of pandemics around the world. It also provides an answer to the query of how the future of IoT networks has been influenced by a global virus epidemic.

Keywords: Role of Internet of things (IoT); Covid-19; IoT applications; Pandemic

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1. Introduction

IoT is abbreviation of Internet of Things, a term that was first presented in a presentation by Kevin Ashton on the implementation of Radio Frequency Identification (RFID [1]. A technology having ability to connect all smart objects in a network without human interactions [2]. We can even put it more simple and say that any object that has ability to connect itself to the internet for additional

monitoring or data transmission can be an IoT device [3]. In times of a global pandemic situation likes Coronavirus Disease 2019 (COVID-19), its essential to adhere to social distancing guidelines and to effectively track and trace patients [4]. It's also observed that indirect contact with patients has been shown to reduce stress for medical staff therefore using smart objects to treat patients at home or checking their status on the web can reduce hospital treatment needs for all patients. Similarly, robots and cameras can help remote doctors monitor people and maintain physical distancing [5], [6], [7].

The Internet of Things (IoT) when formed as a network of sensors for gathering and monitoring data both remotely and locally has been proven beneficial in the health sector especially in electronic health (e-health). [8]. Healthcare is also found to be one of the major industries that have benefited from the advancement of the IoTs[9]. In the health sector, the Internet of Things has drastically altered both young and old people's lives, as they can constantly monitor their health [10]. It is also becoming one of the a revolutionary technology in healthcare systems because it can provide better quality of services and advanced user experiences with reduced expenses [3], [11], [12], [13]. In the current typical situation of COVID-19, most problem occurring due to the inability to effectively reach patients, which is the also most considerable issue after interest in development of vaccine [14], [15]. The concept of the IoTs makes access to patients very useful because it is ultimately allowing them to be given great attention to come out of this disease and therefore ability of this technology to provide remote data collection and tracking of quarantined patients has proven an important aspect in combating the spread of viral outbreaks [16], [9].

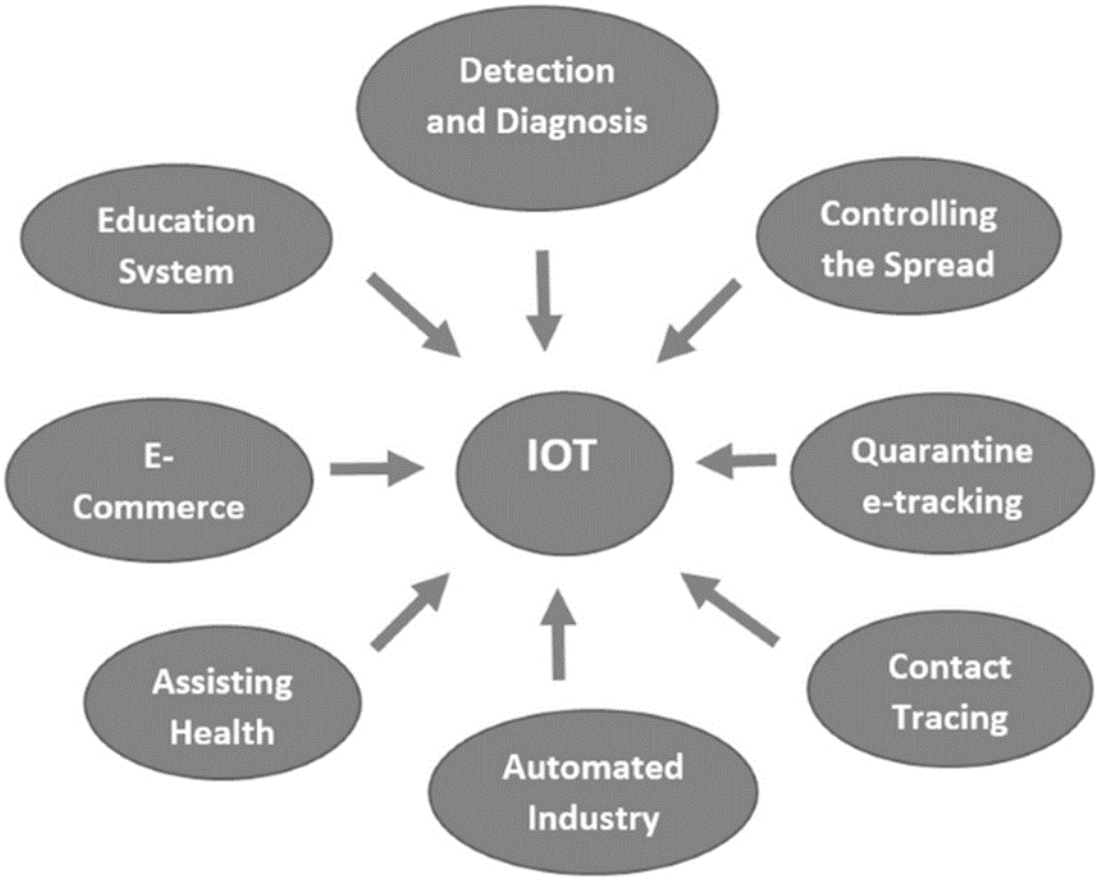

Fig. 1: Represents role of IOT in covid pandemic.

It is evident that the technology we need to put into place right once to stop this fatal disease is not nuclear weapons, but rather technology related to public health [17]. The COVID-19 pandemic chain can be divided and analyzed to provide several solutions with the correct application of IoTs, data science, and particularly big data technology. Additionally, big data analytics offer a promising engine for the Internet of Things to fight global virus pandemics [18], [19]. The exponential expansion of the Internet of Things in healthcare is anticipated to increase from $72 billion in 2020 to 188 billion dollars in 2025 due to its comprehensive capabilities, including tracking, identification, authentication, and data collection [2], [20].

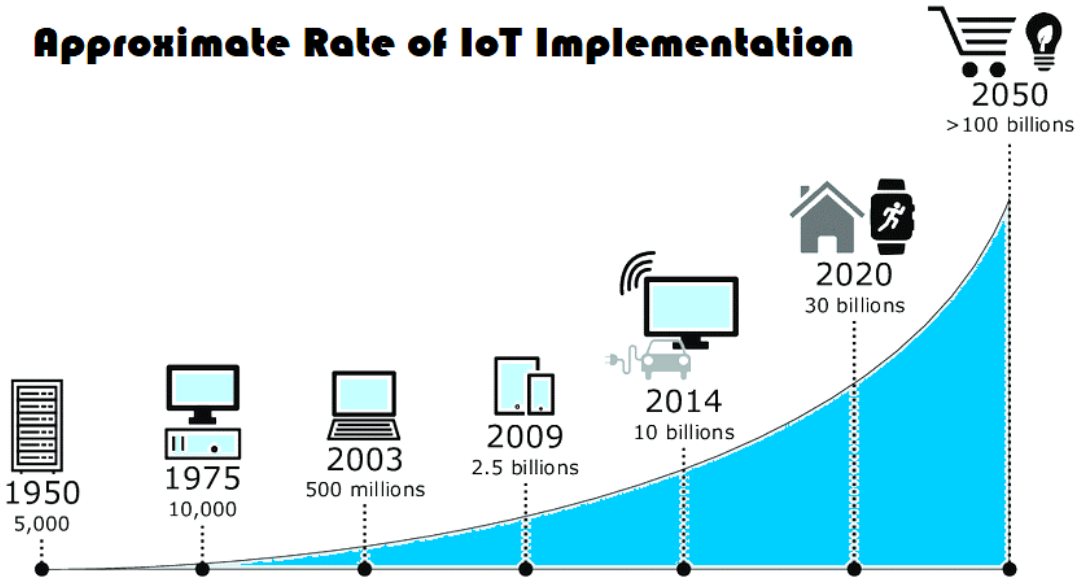

Fig. 2: Represent an expected growth rate of IoT.

As a result, several businesses have accelerated the pace at which they invest in IoT projects [21], [22]. Although the IoT concept is well-liked and is claimed to have advantages, adoption has been much slower than expected [23], [24]. Here are some of the key causes behind this: (1) Problems with security, privacy, policy, and trust [24, 25]; (2) Lack of qualified labor needed for successful IoT adoption due to regulatory blockage, lengthy capital cycles. Fig 3 represents platform of IOT.

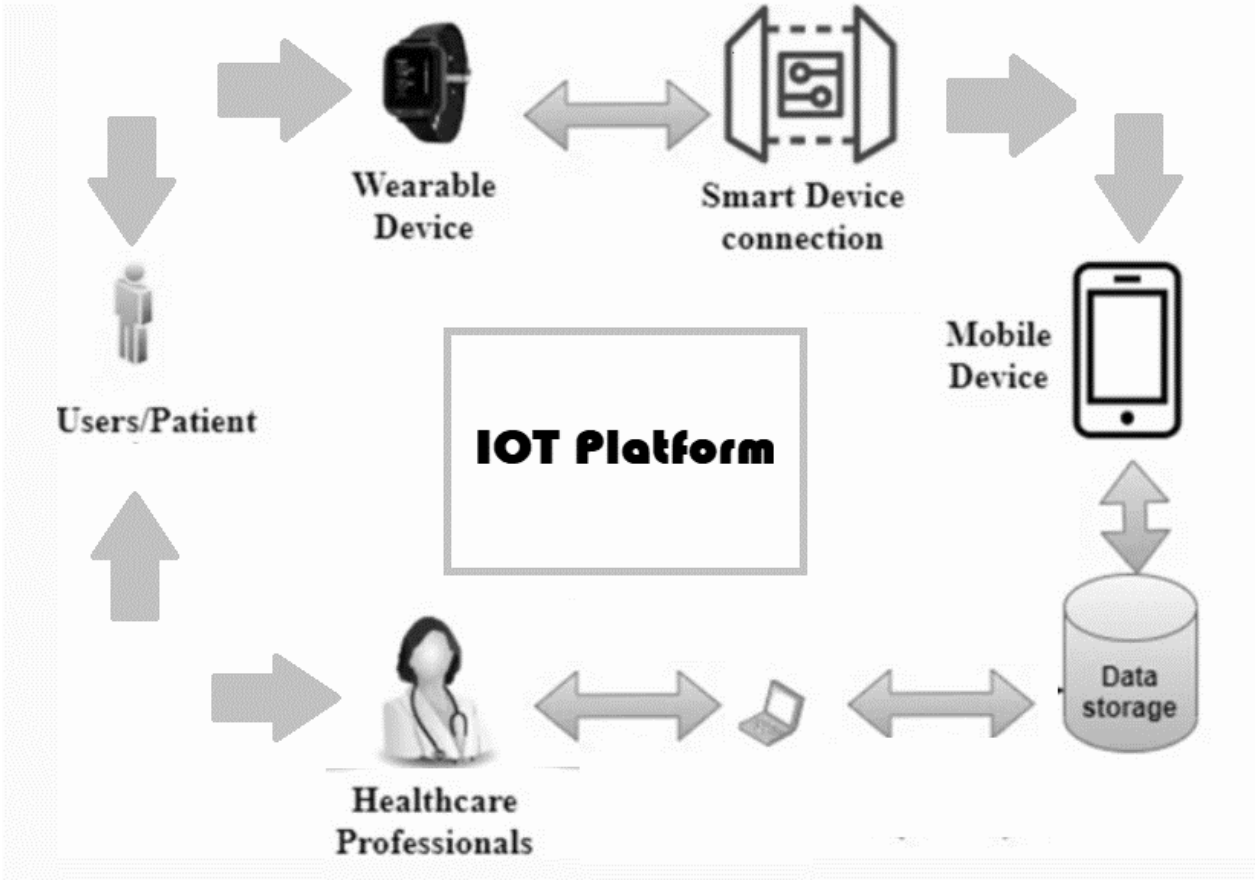

Fig. 1: IOT Platform.

2. Research Methodology

A systematic literature review basically gathers and evaluates already published studies in accordance with predetermined assessment criteria, and as a result, these reviews assist in determining what is already known in the relevant field of study [26]. When the systematic literature is complete, it presents a more sane, logical, and trustworthy answer to the research's main topic. [27]. The goal of conducting this systematic literature analysis was to highlight IoT adoptions and their impact on the post-pandemic world, including the present issues being encountered, as well as the use of IoT during the Covid-19 crisis.

2.1 Research Questions

Forming research questions is essential for carrying out an efficient systematic literature evaluation on a subject. The following table.1 contains a list of the research topics that were developed for our systematic study.

Sr. No	Questions
1.	What is the current role of IoT under current covid-19 pandemic?
2.	Can IoT solutions help preventing and fighting covid-19, if yes How?
3.	What are the major challenges being faced in implementation of IoT technologies for Covid-19?
4.	How IoT adoptions will impact post Covid-19 pandemic?

Table 1. Research Questions.

2.2 Search Strategy

Conducting a well-planned and systematic search is crucial to get relevant information from the sought data of your desired area. We carried out a comprehensive search to separate just useful and pertinent information from the sea of data. The keywords used to search information are listed in table 2.

Sr. No	Keywords
1.	("Contributions" *OR* "Challenges" *OR* "Evolution" *OR* "Technologies" *OR* "Adoptions" *OR* "Solutions" *OR* "Emerging Solution" *OR* "Healthcare Applications") **AND** ("IoT" *AND* "Covid-19")
2.	("Prevention" *OR* "Fighting" *OR* "Control" *OR* "Identification") **AND** ("IoT" *AND* "Covid-19")
3.	("Beyond Pandemic" *OR* "Post Pandemic" *OR* "After Pandemic") **AND** ("IoT" AND "Covid-19")
4.	("IoT" **AND** "Covid-19")

Table 2. Search Keywords

2.3 Resources of Research

To find studies relevant to our topic, we used reputable search engines such as "Web of Science Master Journal Search," "IEEE Xplore Search," and "Google Scholar.".

2.4 Inclusion and Exclusion criteria

Establishing inclusions and exclusions criteria (table 3) helped us setting the boundaries for the literature review as it allowed deciding which studies should be included or excluded in our literature.

Inclusion criteria	Exclusion criteria
InC-1. Articles focusing role of IoT during and after covid-19 pandemic	**ExC-1**. Articles that only discussed IoT challenges, role, contribution, solutions but did not focused Covid-19
InC-2. Articles focusing challenges being faced in IoT technologies for covid-19 solutions	**ExC-2**. Articles that did not discussed impact of IoT under current or post pandemic
InC-3. Articles focusing use of IoT for prevention and controlling covid-19 disease	**ExC-3**. Articles having no citations
InC-4 Articles that were published from 2020-2021	**ExC-4**. Articles that were published before 2020 year.

Table 3. Inclusion/Exclusion criteria.

3. Discussion:

Sr No	Ref	Title	Technique Used	Problem Tackled	Year
1	[28]	Investigating the capabilities of information technologies to support policymaking in COVID-19 crisis management; a systematic review and expert opinions	IT Systems	Policy Making During COVID-19	2020
2	[29]	IoT Platform for COVID-19 Prevention and Control: A Survey	IoT Systems	COVID-19 Preventaion & control	2021
3	[30]	A Measurement Approach Using Smart IoT Based Architecture for Detecting the COVID-19	SmartIoT Based Architecture	Detection of COVID-19	2021
4	[31]	iResponse: An AI and IoT-Enabled Framework for Autonomous COVID-19 Pandemic Management	AI and IoT-Enabled Framework	Automatic Panedemic Management of COVID-19	2021

5	[32]	A Comprehensive Review of the COVID19 Pandemic and the Role of IoT, Drones, AI, Blockchain, and 5G in Managing its Impac	IoT, Drones, AI, Blockchain, and 5G	Mangement of COVID-19 Impact	2020
6	[33]	Future IoT tools for COVID-19 contact tracing and prediction: A review of the state-of-the-science	Future IoT tools	Contact tracing & prediction of COVID-19	2021
7	[34]	Approaches Based on Artificial Intelligence and the Internet of Intelligent Things to Prevent the Spread of COVID-19: Scoping Review	AI, IoT, and Internet of Intelligent Things	Prevention of spreading COVID-19	2020
8	[35]	COVID-SAFE: An IoT-Based System for Automated Health Monitoring and Surveillance in Post-Pandemic Life	IoT based system	Automatically Monitoring the status of health & Surveillance in the Post-Pandemic Life	2020
9	[36]	An IoT-based framework for early identification and monitoring of COVID19 cases	IoT based framework	Early identification & monitoring of COVID-19	2020
10	[37]	16 Application of cognitive Internet of Medical Things for COVID-19 pandemic	Cognitive Internet of Medical Things	COVID-19 pandemic	2020
11	[38]	A Public Platform for Virtual IoT-Based Monitoring and Tracking of COVID-19	Virtual IoT based Techniques	Monitoring a& Tracking the COVID-19	2020
12	[39]	Healthcare Assistance to COVID-19 Patient using Internet of Things (IoT) Enabled Technologies	Internet of Things (IoT) Enabled Technologies	Helath related assistance to COVID-19 Patient	2021
13	[40]	IoT Based Humanoid Software for Identification and Diagnosis of Covid-19 Suspects	IoT based software	Identification and Diagnosis of COVID-19	2020

14	[41]	Opportunities and challenges for the building monitoring systems in the agepandemic of COVID-19: Review and prospects	IoT monitoring systems	Developing monitoring systems in the agepandemic of COVID-19	2021
15	[42]	COVID-19 Pandemic Waves: 4IR Technology Utilisation in Multi-Sector Economy	4IR Technology	COVID-19 Pandemic Waves and impacts of Multi sector economy	2021
16	[43]	Internet of Things (IoT) for NextGeneration Smart Systems: A Review of Current Challenges, Future Trends and Prospects for Emerging 5G-IoT Scenarios	Internet of Things (IoT) for NextGeneration Smart Systems	Future 5G Current Challenges, Future Trends, and Outlook	2020

Mehraeen et al [28] proposed that an artefact or repository is required to store the best practices for the use of IT in pandemic management that are currently available. Professionals from around the world should be able to update this artefact, and conversations about each of the best practices should be supported. Up until this moment, we only looked at two types of difficulties. Some experts think that a third category would involve looking into the causes of the pandemic to stop similar incidents from happening again. These categories are not discussed.

Dong, Y. et al [29] explains how the system for epidemic prevention and control could use the Internet of Things. they describe a prospective fog cloud integrated IoT system that may be used for the methodical as well as knowledgeable prevention and control of COVID-19 in particular. This entails five treatments, including SARS-CoV-2 Mutation Tracking, Contact Tracing and identification, Social Distancing, COVID-19 Outbreak Forecasting, and COVID-19 Symptom Diagnosis.

Poongodi, M. et al. [30] presented a methodology that that can be used to get reliable COVID-19 results, using the mobility tracing procedure as the primary area of attention. All of these specifics have been provided as part of a proposed method, which can be discovered in further depth through simulation-based experimentation.

Alam, F. et al. [31] Elaborated in article about the numerous response framework functions and implementation possibilities are further explained in an article about the framework that contains six case examples. There are few case studies that show how to create sustainability related strategies that are optimal, for pandemic management utilizing seven real-world datasets by utilizing DL or Deep learning and other methodologies. These comprise a sentiment analysis case study, the identification of human actions, and sentiment analysis. From these case studies, a number of important insights are gleaned.

Chamola, V et al. [32] presented a detailed report that emphasizes the COVID-19 outbreak's effect on the world economy as well as its immediate health repercussions. they conclude by thinking about how emerging technologies, including the Internet of Things, Unmanned Aerial Vehicles, blockchain, (AI), and 5G, may affect the COVID-19 pandemic.

Jahmunah, V et al. [33] In the event of future global health emergencies, the proposed method might also be employed to reduce disease occurrence. It is made comprised of a wearable device and phone application that support COVID-19 analysis and have unique IoT features built in like complex data analysis and visualization of data in an intelligent manner. Applications for tracing contacts must specify how data are collected and analyzed. Epidemiological professionals can detect clusters and take the necessary actions to improve public health administration with the use of intelligent data interpretation.

Adly, A. et al. [34] provided a detailed review of approaches based on AI and IOT to reduce the spread of covid it is suggested that researchers should place more emphasis on certain approaches, such as using AI for COVID prediction, modelling, using AI robotics for medical quarantine because these crucial approaches don't have enough studies.

Vedaei, S. et al. [35] The proposed system consists of lightweight as well as low cost IoT nodes, smart mobile phone applications (apps), and Fog-based machine learning (ML) tools for data analysis and diagnostics. The mobile app updates to reflect the user's health status, and IoT nodes track health metrics such as temperature of body of patient, respiratory rate, cough frequency, and blood oxygen saturation. To prevent the spread of viruses, the software asks users to maintain a physical distance of 2 m. The fuzzy Mamdani algorithm (running on Fog servers) also considers user health and environmental hazards while estimating the likelihood of infection spreading in real time.

Otoom, M. et al. [36] advocates using these real time symptom data to detect potential coronavirus cases using 8 ML techniques, including SVM also called support vector machines, Neural Network, Naive Bayes, K-Nearest Neighbor, Decision Table, Decision Stump, OneR, and ZeroR. After the relevant symptoms were selected to evaluate these eight algorithms on the real COVID-19 symptom dataset an experiment was performed or conducted. As a result, 5 of these 8 algorithms showed over 90% accuracy.

Swayamsiddha, S. et al. [37] address an issue, the CIoMT, that is cognitive issue of MT or medical things is, n unique application of cognitive radio based IoT tailored for the health sector, is being investigated. Given that every individual will be connected as well as observed & monitored through a sizable network that necessitates effective spectrum management, the IoT idea is most adapted to this pandemic.

Jung, Y., et al. [38] proposed technique that utilizes the international centers for Disease Control and Prevention and regular users can access real-time information disclosure services thanks to the Software-Defined Networking Controller, which is available on the global public platform. People who are on the CDC's list of people who need to be watched in regard to the COVID-19 are forcibly installed with the COVID-19 vIoT nodes, in form of smartphone apps.

Mukati, N., et al. [39] research was done to find solutions to connected issues and stop the COVID-19 epidemic. The important IoT accomplishments were promptly evaluated using a process diagram. It identified and showed seven key IoT technologies that are important to medical industry during the COVID, and it highlighted as well as briefly explained potential fundamental Internet of Things apps for the healthcare sector.

Karmore, S., et al. [40] established a system that is based on AI for health sector, where humanoids can travel to designated regions, diagnose a person for Covid using different parameters, and do an area survey for it. Various sensors of ML are used to create the humanoid leverages and real-time data sensing and processing.

Al-Humairi, et al. [41] covered the most recent innovations that have been used to successfully interface with the building management infrastructure and reduces and minimize the spread of COVID using embedded smart monitoring systems. the desired sustainable development goals are encouraged by the statistics study analysis (SDGs).

Agbehadji, I. et al. [42] evaluated the limitations of 4IR technologies as they were applied during the COVID-19 pandemic waves. Recent research articles were carefully read and retrieved from an internet repository to emphasize the applications, innovations, shortfalls, and cross-sector problems of 4IR technology. The second pandemic wave had a reduced frequency of thrombotic events and a smaller proportion of patients who required invasive mechanical breathing, according to the review's findings. It was further demonstrated that the second wave in the healthcare sector saw a longer delay between ICU admissions and tracheal intubation.

Shafique, K., et al. [43] presented in-depth review of the new 5G-IoT scenario. The widespread use of IoT technology requires key enabling technologies, which 5G cellular networks provide. Device to device connectivity, coordinated multipoint processing, massive MIMO, coordinated multipoint processing, software defined wireless sensor networking and carrier aggregation.

4. Conclusion

Numerous technological remedies have been implemented to battle the COVID epidemic, which is still wreaking havoc on the earth. IoT or Internet of Things, has been heavily exploited in the health sector. Effectiveness of this approach in combating the COVID-19 outbreak is highly encouraging. To inform this article, we have organized a survey of new IoT devices proposed to support governments and medical professionals during the COVID pandemic. We have examined the uses of IoT related technology.

By properly and securely integrating IoT technology, most of the patients can use IoT devices to participate in their treatment with mental relaxation and ease. As a result, governments and medical experts can combat pandemics more successfully. As a result, the negative effects of many diseases can be reduced, spread of infections, hospitalizations, and death rate, can also be controlled and minimized.

A new generation of sensor deployment models and IoT methodologies have been developed in response to the COVID-19 IoT technology challenge. In order to analyze and assess the evolution, This paper compared the state of IoT in medical sector before and after the COVID-19 outbreak. One of the main conclusions of this study is that social acceptability and security of data exchange in IoT management systems is required for IoT to meritoriously support the war against the pandemic. The greater accessibility of high quality, accurate data will enhance the containment and surveillance of a virus that spreads swiftly like COVID-19.

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