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# The Effects of IoT after COVID-19 on the Modern Healthcare Industry

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***Abstract:*** ***In the last several years, IoT applications in the healthcare sector have skyrocketed (IoT). The major goal of IoT is to provide people with the basics they need to survive in these uncertain times. The availability of IoT-based healthcare solutions is critical during this pandemic. The IoT allows for more precise diagnosis, better treatment, and closer monitoring of patients. IoT technology can fundamentally overhaul the present system, and academics have been working around the clock since the beginning of the pandemic to discover answers. By the time this report was completed, about 6 million individuals had lost their lives to the COVID-19 pandemic. Many lives may have been avoided. People can't call an ambulance, can't locate one, and can't get to the hospital safely when they're too ill. People in extreme situations may instantly summon an ambulance or other emergency contacts by pressing a button on their phone or using a voice-enabled device. According to the findings, this might be a life-saving breakthrough if it is taken seriously by significant businesses.***

***Keywords: IoT, Smart Healthcare, Covid-19, Health Analytics, Proactive maintenance, Pandemic, Healthcare Management Life support***

## I. INTRODUCTION

One sector that stands to gain significantly from the "Internet of Things" is healthcare (IoT). It's possible that this will have a beneficial impact on society and might even save lives [1]. Everyone in your sphere of influence might perhaps gain from using this tool. A device that may be used on many different gadgets or built into them might save the lives of the elderly and others who are unable to call for help. The usage of this technology may lessen the number of people who lose their lives because they couldn't get help in time. The rise of the Internet of Things (IoT) as a research field has been especially beneficial to the healthcare sector in recent years. Current healthcare systems are being affected by the Internet of Things (IoT). Patients' access to and results from diagnosis, treatment, and monitoring have improved as a result of this transition from universal to individualized approaches [2]. This new medical development has the potential to save countless lives if it is utilized correctly. By just pushing a button on their mobile devices, doctors and nurses can check in on their patients and find out right away whether they need assistance. The Internet of Things (IoT) might help improve the quality of medical care given to patients.

The data provided by buttons like these are crucial in guiding doctors toward the most appropriate treatment plans for their patients [1].

IoT's real-time data collecting, processing, and reporting capabilities, it has transformed many business ecosystems (IoT). There has been a dramatic increase in efficiency and several lives saved in healthcare facilities because of sensors and other IoT-enabled devices. The IoT enables the internet connection and wireless data sharing of commonplace things. Embedded systems, machine learning, real-time testing, sensors, and many more are just some of the technologies that have grown out of and contributed to the IoT concept.

IoT will have far-reaching effects on the healthcare industry because of the number of procedures it can automate. With a CAGR of 19.8 percent between 2019 and 2027, the healthcare IoT market is expected to balloon from $58.3 billion in 2019. IoT has boosted speed and efficiency in patient care, especially during COVID-19. Let's take a look at how the Internet of Things (IoT) is changing healthcare and the opportunities it's presenting with COVID-19. [9]

This includes not just the idea of a "smart" hospital, but also any supplemental wired or wireless infrastructure. Intelligent devices may gather and transmit information that is critical to achieving a goal.

Many sectors stand to benefit from the IoT, including but not limited to electronics, media, transportation, urban infrastructure, healthcare, and the healthcare sector. The foundation of IoT applications in healthcare comes from sensors, medical devices, artificial intelligence, and cutting-edge imaging technologies. Existing companies and new communities alike may profit from these technological developments [1].

 


Fig. 1. Use of IOT in Healthcare Systems

Through the "Internet of Things" (IoT), linked devices may automatically share information. Amid the current COVID-19 Pandemic, this development is prospering in the health monitoring field. There are now many early deaths that may be attributed to inaccurate health information. In this technique, sensors are utilized to detect potential health problems at an early stage [2]. COVID-19 stores all patient data on the cloud, which might improve the quality of treatment.


Fig. 2. All the Information obtained is stored In the cloud for future use

This gadget can track a user's behavior and alert them to any health problems before they become serious. The success of any medical procedure depends on having access to the appropriate equipment. The Internet of Things (IoT) can streamline surgical procedures and post-operative evaluations. Therefore, the usage of IoT enhances the medical care given to patients during the COVID-19 Pandemic. The Internet of Things has the potential to aid in the monitoring of a wide variety of conditions, including diabetes, heart failure, asthma, hypertension, and others. Connecting smart medical devices to a mobile device may provide clinicians instantaneous access to up-to-date patient data. Metrics such as blood pressure, body mass index, and glucose levels are monitored. The medical community required a trustworthy digital information system during the recent COVID-19 epidemic [3, 4], and the IoT delivered. To keep up with the demands for improved product quality, it might be difficult to investigate the benefits and uses of new technologies. In the event of a COVID-19 pandemic, however, its improved capabilities will allow it to address a wide range of problems by making use of up-to-date information.

## II. THE ROLE IOT DURING COVID-19

Patients with a broad range of illnesses, including COVID-19, may benefit from IoT. Since it is considered impolite to leave one's house if one is experiencing symptoms of, or has, COVID-19, people all over the world are being untreated for deadly illnesses. One such tool is a ring or chip that may detect a weakened immune system or a general sensation of being under the weather [3]. Using this device, you may contact emergency services, get admission to a hospital, and receive treatment from nurses and doctors who will hopefully make you feel better and perhaps save your life (see Fig1). If you have lips or skin that are pale, grey, or blue; if you have persistent pain or pressure in your chest; if you have trouble staying awake; if you have recently become disoriented; or if you have any of these other symptoms, the Centers for Disease Control and Prevention advise that you seek immediate medical attention.

The inability to seek care promptly owing to disease or a false feeling of safety is a problem not only with mental health issues but with a wide range of other ailments as well. While isolated at home, many people who could have had COVID-19 tried to contact for medical assistance, but they might not have been able to walk across the room to pick up the phone. The victim and their loved ones may go through unfathomable suffering. With this knowledge, an IoT-connected gadget may potentially keep tabs on immune system data and spot any defects or medical issues, which would be very helpful to society and help cut down on premature deaths (see Fig. 1).

*A. Automated Sanitizing and Higine Checks*

Robots and sensors enhanced with artificial intelligence are among the cutting-edge technologies that businesses of all stripes are eager to use. In the future, advanced robots may help humans do a broad range of potentially dangerous tasks. Robots might be a huge help in healthcare facilities and affect community sanitation activities. It will help maintain cleanliness and protect sanitation employees from becoming sick. Additionally, non-surgical robots may be employed to disinfect patient rooms. Although extended exposure to UV radiation may cause skin damage in humans, it may be used by robots to disinfect rooms. Sensor-based hand hygiene devices might be used to prompt patients, workers, and others to wash their hands. When a room has been cleaned and disinfected, robots might send out a signal to let people know it is ready to be used. Disinfection should be more effective now that we have Internet of Things-enabled devices and robotics.


Fig. 3.IOT Flowgraph for Healthcare

*B. Person to Person Contact Tracing in Real-time*

Covid-19 is the world's fastest-spreading virus, and it may occasionally affect its hosts without them even realizing it. During the incubation phase, it is very important to trace the infected person's future interactions.

Developers of Internet of Things apps have made useful tools that may be used in various contexts. Since fever is one of the earliest indicators of the condition, it may be possible to gather data on individuals who have it by using smartwatches and thermometers with built-in sensors to track their core body temperatures. Data from an infected person may be analyzed using AI and Big Data methods once it has been collected. It is feasible that most regions impacted by Covid may be identified and contained with the use of technology. Effective quarantine and isolation measures may also be implemented by the government. Wearable technology, such as RFID (Real-time location system) wristbands, might be used to monitor a patient's health while they are in seclusion and undergoing rehabilitation. Insight into the virus's properties and further scientific investigation might be gained from the data acquired by these technologies.

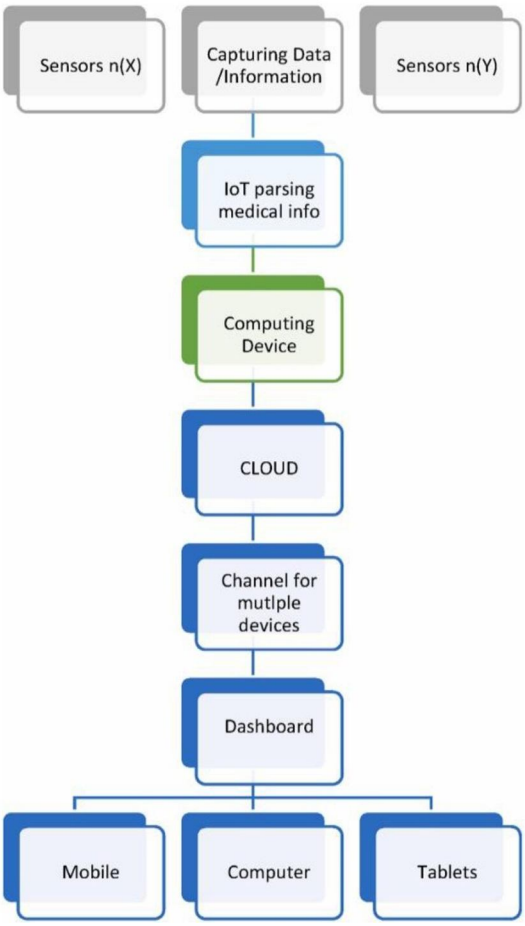


Fig. 4.IOT parsing medical information

## III. INTEGRATION OF IOT IN THE MEDICAL FIELD

Internet of Things services are cutting-edge because they use cutting-edge technology. When the best possible treatment is found for patients with COVID-19 and extremely precise surgical treatments are made possible, that is when a novel medical idea comes into its own. Complex problems are now easily solvable and technologically controlled [4] since the previous outbreak. The Internet of Things (IoT) might help us overcome insurmountable barriers to create better medical support systems for doctors, patients, and surgical teams. Properly implementing the IoT requires adhering to a predetermined set of steps. Workflow diagram for the Internet of Things in a hospital setting.

If a person with a pacemaker or diabetes has access to the Internet of Things devices that monitor their heart rate, blood pressure, and blood glucose, they may be able to live freely in their own homes, provided they tell their doctors about it. If data from IoT devices indicates that a person needs medical assistance, the individual may be kept under close watch at home or sent to the hospital [10]. Because of the widespread development of COVID-19 in nursing homes, physicians looked for less risky ways to treat the elderly and chronically sick. Healthcare IT News has reported on the possibility of using disaster relief funding for remote monitoring and virtual visits to reduce transmission risk.

## IV. ROLE OF IOT IN HEALTHCARE MANAGEMENT

Remote monitoring in healthcare, made possible by the IoT, has the potential to increase patient safety and aid physicians in providing superior care. Patients were more likely to agree with and comprehend their physicians' explanations of health issues as a result. Readmission rates may be lowered and hospital stays can be cut short with the use of remote health monitoring. The effectiveness and quality of medical treatment are also significantly affected by the IoT [5]. There is no doubt that IoT has an impact on healthcare due to the rise in connected devices and the diversification of user engagement strategies. Internet of Things medical applications may help patients, their families, doctors, hospitals, and health insurance companies.

Fig. 5.Nurses replaced by robots in healthcare

*A. IoT Applications in Patients*

Wearables like activity belts and glucometers are just a few of the many wirelessly linked medical gadgets available to patients today. Location, facility stay duration, vital signs, calorie intake, and activity levels are just some of the data that may be recorded by such devices. One of the numerous ways the Internet of Things has improved human life is by making it possible to monitor people's health, especially that of the elderly. The results have been terrible for individuals and their families. The alarm system alerts loved ones and medical staff in the event of an unexpected disruption to normal routine [6].

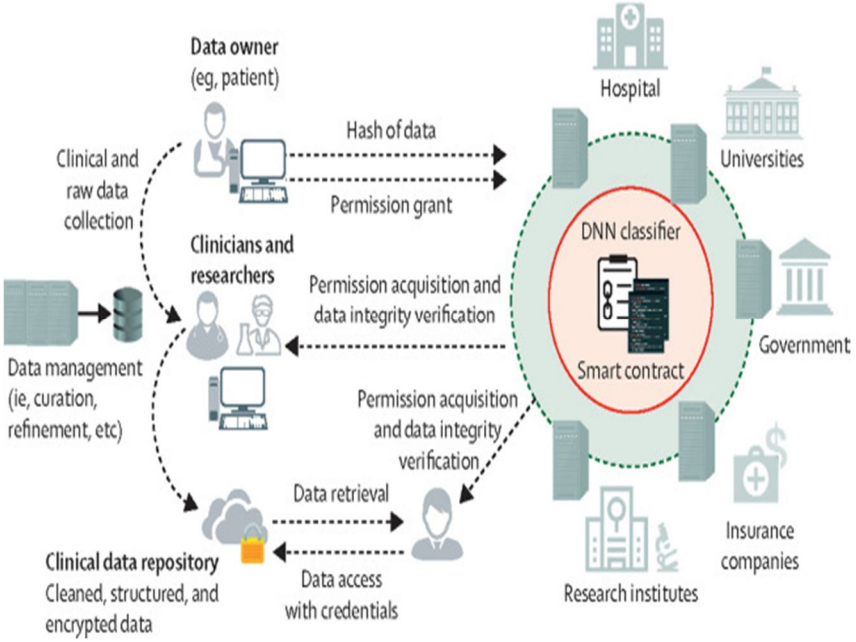


Fig. 6.Blockchain Applications in health care for COVID-19

*B. IoT Applications for Physicians*

Wearables and other Internet of Things (IoT)-based home monitoring devices allow doctors to keep a closer check on their patients' health. Anyone may monitor a patient's progress toward treatment objectives, and anyone can assess whether or not the patient needs emergency medical attention. Thanks to IoT, physicians can now provide the preventive care their patients need. Data from Internet of Things devices may help doctors figure out the best treatment plan for their patients.

*C. IoT in Hospital Establishments*

IoT devices have shown their utility in hospitals beyond only vitals monitoring. Wheelchairs, defibrillators, nebulizers, and oxygen pumps are just some of the medical devices that are tracked in real-time. Medical staff shifts may be monitored in real-time at many hospitals. While hospitalized patients are at high risk of contracting an infection, that risk might be reduced with the use of hygiene monitoring devices made possible by the Internet of Things. Refrigerator humidity and temperature, for instance, might be controlled by an IoT device [7].

*D. IoT for Healthcare Insurance Companies*

Many healthcare insurers stand to gain from the increasing use of Internet-enabled smart devices. If sufficient information is gathered from health monitoring devices, insurers may utilize it in premium calculations and claims adjudication. They may use this data to screen out fake members and recruit more genuine ones. Insurance companies may improve their underwriting, pricing, claims administration, and risk assessment by increasing their customer communication via the use of Internet of Things devices. Consumers will have a good enough awareness of the assumptions behind each option and process outcome across all operational processes thanks to the IoT's capacity to acquire judgments based on data. Offering discounts and other incentives may be one way in which insurers encourage their clients to utilize and share IoT medical data. Customers may use the Internet of Things devices to track their routines and make sure they are sticking to their healthcare regimen. There might be a significant drop in the number of insurance claims as a result of this. Using information received from IoT devices might help insurance companies evaluate claims [8].

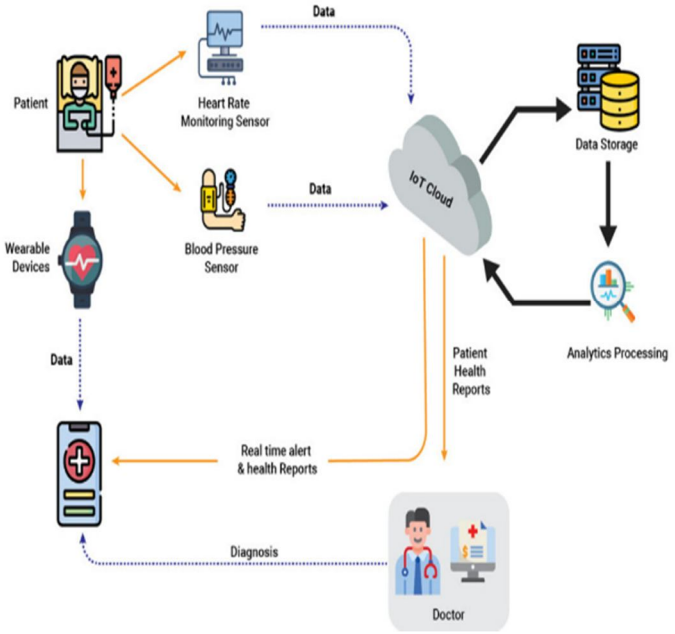


Fig. 7.Data processing and analysis of results in the IOT system

## V. IOT AND WEARABLES

Several recent technological advancements have shown the potential in slowing the disease's progress. A chip placed in a patient's arm might track vital signs and immune system activity, making it easier for physicians to spot illness and persuade individuals to visit a doctor. It's also not out of the question to picture a fitness or health-tracking ring with similar features to those found on modern wristwatches. The patient's blood, immune system, and the urgency of the need for medical treatment are all things that may be monitored (see Fig 2)

This ring has the potential to revolutionize healthcare, flood the Internet of Things with data, and provide scientists insight into the human body that has previously been unavailable to them [4]. Then, the idea of a device that can be triggered by touching the back of a smartphone or computer is put forward (see Fig. 3). This switch would be hidden from sight to avoid inadvertent activation. With the use of wearables like a piece of jewelry, it will be possible to track a person's vitals wherever they go. This necklace or bracelet has the potential to monitor the wearer's health and immune system, allowing it to pick up on the early warning signs of serious illness. The necklace or bracelet can assist rescue workers find you quickly if you're ever in an emergency. In addition to tracking heart rate, this wearable gadget keeps tabs on body temperature and immune system activity [4]. If this device detects a rapid change in your body temperature or determines that anything is wrong with your heart, it will transmit an alert to emergency services and disclose your location. The Internet of Things (IoT) and medical care might both benefit greatly from the use of such devices [5].

*1)* Heart Rate Monitoring-- determining the patient's heart rate based on their level of exercise.
*2)* Mood Monitoring —to grasp the patient's mental state
*3)* Patient Monitoring-- Learn to take your vitals, including temperature, heart rate, and blood pressure.


Fig. 8. Smart wearables for healthcare by IOT

## VI. DATA COLLECTION AND ANALYSIS

Data analytics provides enormous value when applied to the huge volumes of data created by connected Internet of Things devices. IoT analytics as a patient-facing tool and health-conscious equipment might have significant implications for the medical industry. These gadgets' designs show great potential for increasing the IoT's use in the medical field [5, 6]. External cameras or other networked transparent devices might see the data acquired by the Internet of Things wearables' internal sensors. Researchers at hospitals and other medical facilities may use the transferred patient data to improve diagnosis and treatment options (Fig. 4).

Using IoT analysis, many people may be saved from passing out due to COVID-19 or other medical conditions. Patients, doctors, and others all benefit from this approach since it gets to the bottom of the problem. To ensure a varied range of sources and to avoid inaccurate inferences from a single set of results [7, 8], it is strongly suggested that data collecting be carried out through several devices. IoT data analytics is the study of the massive volumes of data created by connected devices, made possible by advancements in smart city design [10]. It might help businesses streamline their operations, automate their clinical trial management, expand their customer base, gain the trust of more patients, and empower their workforce [9, 10].

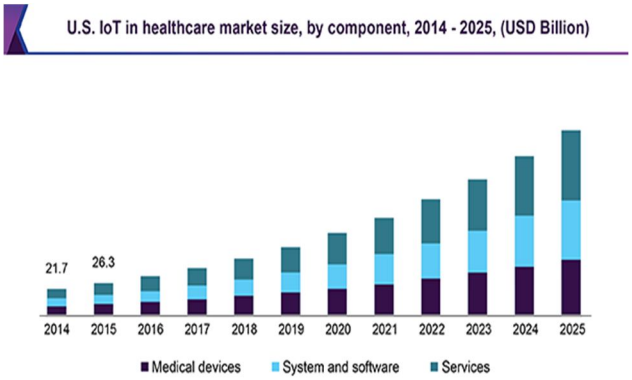


Fig. 9. US IoT in healthcare market size

## VII. EXISTING HEALTHCARE MONITORING SYSTEM

Thanks to a recently established approach, the start of health issues may be predicted. They were unsuccessful in meeting the benchmark because inappropriate machine-learning models were used. Within the archive, there were not a lot of active records. Although the models may be constructed, they would be impossible to use without a user-friendly interface. It's difficult for a normal person to acquire. Some current technologies just display symptoms of sickness; they are unable to diagnose or provide insight into the patient's condition [9]. Inadequate knowledge makes it difficult for individuals to cope with even the most basic health problems. Residents in rural regions have restricted access to the electronic health system since health-related tests are widely available but relatively pricey and maintaining a health monitoring system requires a lot of physically demanding activities. Researchers in the fields of healthcare [13–18] and transportation [19–25] have published a plethora of methods for keeping interoperability data secure. Researchers have devised many methods [31–35] for IoT-based applications. Image secrecy is one such example [26-30].

### *A. Telehealth Consultations*

Due to the extremely contagious nature of the illness, doctors and patients must use video chat to identify whether they have been infected. Communication strategies that depend on technology and the physical constraints of healthcare and nursing institutions are easily replaced by the acute viral variants common in these settings.

*B. Digital Diagnostics*

After a computerized diagnosis has been established, many Internet of Things devices track patient information. Kinsa's smart thermometers might help make communities healthier and safer by sharing data with physicians and analyzing patterns.

*C. Robot Assistance*

Connected robots are becoming more commonplace. Time spent on hospital cleaning, sanitization, and medicine delivery might be redirected to better serve patients. UVD robots, created by a firm in Denmark, are now being used for the first time in the world to clean hospitals in China. These robots use the Internet of Things to keep hospitals and nursing homes clean.

*D. Tracking*

Epidemiologists may be able to track the spread of disease across a community with the use of Internet of Things-enabled monitoring thermometers. This kind of data helps pinpoint potential hotspots for local disease epidemics. If this targeted collection and distribution of clean, anonymous data could lead to the development of a user profile that is unique to each user, that would be even better. Thermometers that are comparable [11].

*E. Vaccine Cold Chain Monitoring*

During COVID-19, it was difficult for underdeveloped nations to coordinate their immunization services. Mobile and IoT technologies may help streamline the distribution of vaccines. Internet of Things (IoT) sensors are embedded in vaccines, and mobile data networks enable cold chain data recorders to reliably transfer vaccine storage conditions to the cloud. The United Nations Development Programme (UNDP) and the government of India worked together to create an Internet of Things (IoT)-enabled mobile device called eVIN to enhance cold chain logistics in real-time. The effort ensures that vaccinations are delivered safely and reliably by using Internet of Things (IoT) sensors embedded in the goods to track their position, temperature, and supply. In India, 80% of the vaccination supply was wiped off [12] because of eVin.

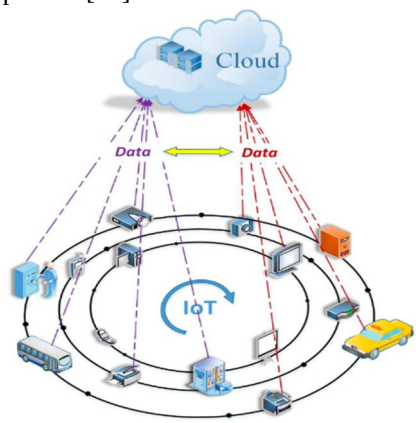


Fig. 10. IoT System for Smart Cities

*F. Healthcare Delivery Drones*

People in remote regions of developing countries often lack access to basic medical services like diagnostics, EPIs, drugs, and more. This is why Internet of Things-enabled drones are so important. Zipline may help remote clinics in Ghana and Rwanda get much-needed medical supplies by May 2020. More than 2,500 hospitals and health centers in Rwanda and Ghana received medication from the drone company during the outbreak. Several different types of drones were used to survey the damaged regions for debris and possible COVID contamination.

*G. Disinfection Process*

Clean and sterilize patient rooms and provide new UV radiation treatments that are more effective at killing COVID-19 with the help of internet-connected, non-surgical robots. The robot always closes the door behind it as it enters a room, presumably to avoid being blinded by the brightness. When an employee leaves a room, the robot politely but persistently asks them to remember to lock the door. These make working in healthcare facilities, such as hospitals, easier for frontline staff and speed up the process of restocking patient cabinets.

Patients were already being helped by the Internet of Things before the general public became aware of the problem. The elderly are particularly vulnerable, but the Internet of Things (IoT) is helping to monitor their insulin levels, exercise regimens, and pacemaker pulse rates. The usage of wireless, networked technology may shorten reaction times in emergencies and enhance remote monitoring. The Internet of Things can keep an eye on vital systems and send out warnings if something goes wrong. Immediate assistance might be sent in the event of a wheelchair tipping over, a nebulizer malfunctioning, or an oxygen tank running low. Medical IoT has continued to protect patients and medical workers [7] despite the COVID-19 pandemic. Future projections show this trend sustaining and maybe picking up speed.

## VIII. DATA PRIVACY AND PROTECTION

There is a lot of sensitive data stored in the healthcare sector. Ever since then, hackers have often targeted it. Patient records and other relevant data will be digitally stored in the cloud as we make the shift to an all-digital healthcare system. In conclusion, cloud-based medical record sharing is inevitable, but it must be implemented with strict confidentiality safeguards to ensure the safety of both physicians and patients. The Internet of Things might be utilized to enhance security in these settings, protecting both patients and authorized workers. Healthcare insurance firms might use the data for a variety of purposes, including underwriting and claims management. They might use this data to learn more about the incidence of false claims and attract new underwriting customers. In short, Internet of Things devices will allow for more open communication between policyholders and insurers in terms of premiums, claims, and risk assessment. Customers may always have a critical understanding of the rationale behind every action, thanks to the transparency of IoT-recorded data and decision-making procedures.

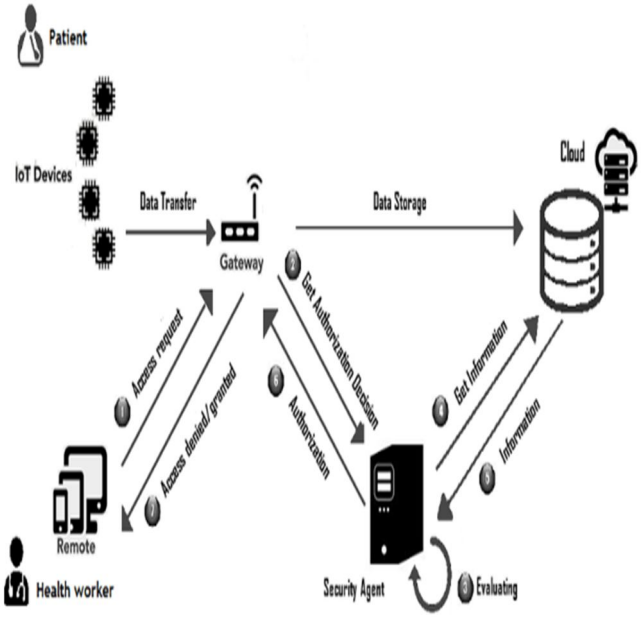


Fig. 11. Privacy and Security management in IOT-based Healthcare Systems

## IX. CHALLENGES AND OPPORTUNITIES

A lack of infrastructure and resources is a common obstacle to establishing the Internet of Things (such as connections, electricity, spectrum, bandwidth, and cost). However, the widespread use of mobile broadband (including sensors) and cost-cutting IoT applications in healthcare are anticipated to expedite these developments. Standardized low-energy wireless technologies are becoming more affordable, which is a positive development. The rising use of technology in healthcare has generated concerns about the privacy and security of patient information. Because of these concerns, industrialized countries have adopted national IoT guidelines [6]. To further use the Internet of Things, however, suitable legislation is still required. Last but not least, IoT-based healthcare is notoriously unreliable. The vast majority of medical disorders can only be correctly identified by a thorough physical examination. More caution is needed when using telemedicine delivered through the Internet of Things. The involvement of cell phone service providers might speed up the use of IoT in healthcare. The controller is a firm that provides these kinds of cold-chain monitoring devices.

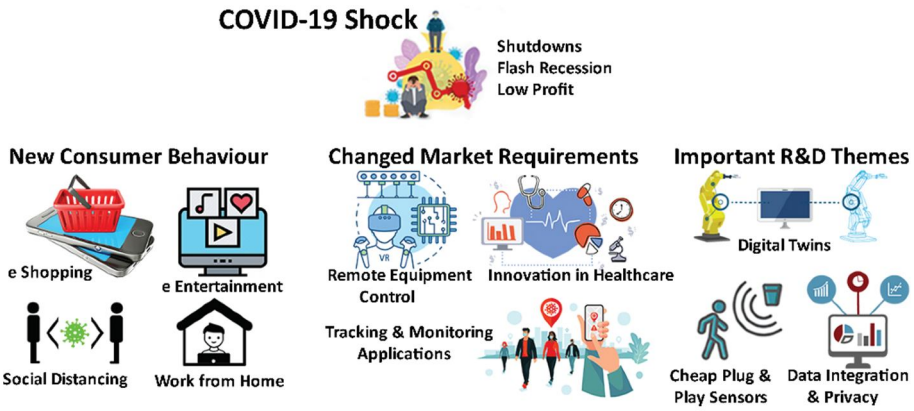


Fig. 12. IoT-based healthcare System in COVID 19

This organization and Vodafone Mobile Operator, who are partners in a joint venture, utilize the Vodafone Managed IoT Connectivity Platform to keep a close check on data from the Controlling Vaccines project. To expand beyond its current markets in Europe and the Americas, the company is beginning test operations in Kenya and Nigeria. With the support of these mobile partnerships, the potential for IoT-enabled healthcare in underserved regions will increase.

By helping to close large gaps in cost, quality, and access, IoT technology offers developing nations an opportunity to successfully address COVID-19 and, more particularly, to advance the digitization of health systems. Future Internet-of-Things research may employ statistical techniques, artificial intelligence, and big data to anticipate pandemics like COVID-19. For this reason, the IoT may soon play a pivotal role in facilitating the shift from a reactive to a proactive healthcare model [3].

## X. CONCLUSION

People's health might be enhanced, and perhaps saved, via the Internet of Things. We can handle medical crises, treat patients better, promote healthful habits, and track sickness rates. The Internet of Things might save countless lives by vastly improving healthcare systems. The patient's quality of life may improve as a result of these developments because of improved access to information and enhanced two-way communication. This technology will be utilized to improve medical care and guarantee people can maintain their health in the event of a pandemic like the one triggered by COVID-19. As a consequence, fewer individuals will perish from communicable illnesses and other medical complications. The Internet of Things has tremendous potential to improve healthcare. Thousands of lives might be spared thanks to IoT. Pandemics of infectious illnesses like COVID-19 and the deployment of IoT devices to depict and help patients are two examples of possible uses.

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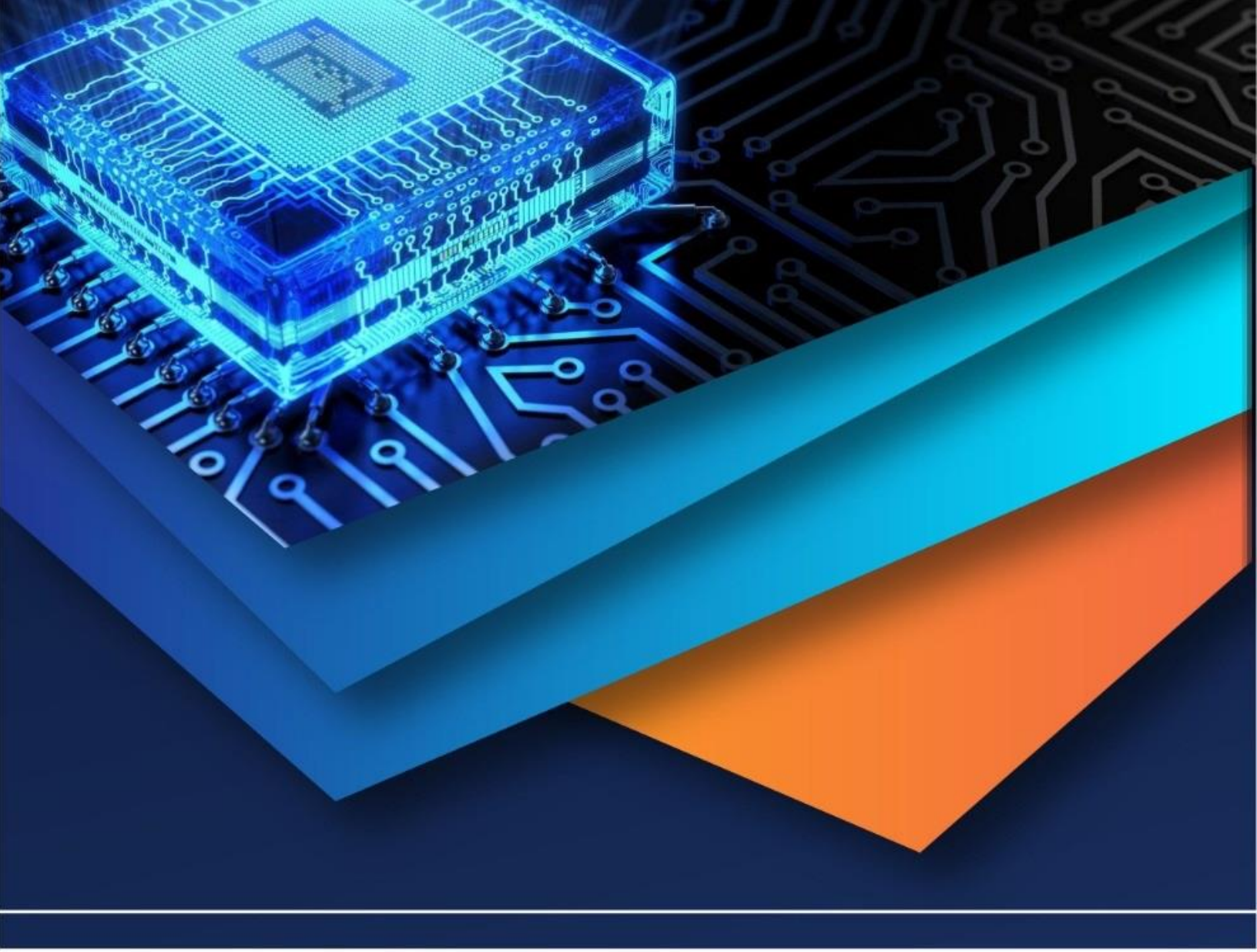

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