International Journal of Computing and Digital Systems
ISSN (2210-142X)
Int. J. Com. Dig. Sys. 13, No.1 (Mar-23)

http://dx.doi.org/10.12785/ijcds/130146

A Survey of IoT Systems for Critical Hospital Cases

Arwa Hamed Salih Hamdany [1], Ahalm Fadhil Mahmood [2]

[1] Department of Computer Technology Engineering, Technical College of Engineering / Mosul, *Northern Technical University, Mosul, Iraq*
[2] Computer Engineering Department, University of Mosul/College of Engineering, , *Mosul, Iraq*

arwahamid78@ntu.edu.iq, Ahlam.mahmood@uomosul.edu.iq

Received 27 Oct. 2021, Revised 18 Apr. 2022, Accepted 5 Mar. 2023, Published 16 Mar. 2023

Abstract: The Internet of Things plays an important role in health care, as there are many health applications through which the Internet of things can be used, and the most important of these applications is the so-called telemedicine, as it can be applied in hospitals to track the number of patients and determine the appropriate medication for them, in addition to following the development of the health status of patients. Telemedicine has been certified for its convenience, time-saving, and intelligence features thanks to the development of the Internet of Things and cloud computing. Therefore, telemedicine technology will see further improvements that support communication between clinicians and patients across space and time. In the presented paper, a body of literature dealing with the telemedicine process has been reviewed for many critical cases in which the Internet of Things is being adopted as an essential technology for the treatment and follow-up of patients in hospitals. The most important aspects of this literature are highlighted in terms of sensors, devices, processors and even communication methods used, as well as means of storing and analyzing patient vital data collected from patients to provide real-time interaction. The most important failures and obstacles in this literature have been identified and appropriate suggestions have been made to reach an integrated health care system based on the Internet of Things. The focus has been on several aspects including safety, network traffic flow, and energy consumption for achieving the requirements of smart hospitals and transition to E-health care.

Keywords: Internet of Things (IoT) , Critical Cases, Telemedicine, E-health, Smart Hospitals

1. INTRODUCTION

Health is an essential element in the development of the individual, and for this, it is necessary to provide appropriate ways and means to ensure the provision of appropriate health care for them. The development and implementation of new technologies, especially wireless sensors for the Internet and Networks (WSN), known as the Internet of Things (IoT), allows a global approach to the development of infrastructure for the healthcare system. This results in an electronic health system that provides, in real-time, a valuable set of relevant information to all stakeholders (patients, medical and paramedical objects, health insurance) regardless of their current location [1].

The Medical Internet of Things revolves around static solutions, medical databases, and connected professional equipment. The Healthcare Internet of Things is a set of different technologies and devices used to support telehealth, providing an easy way to exchange information between specialized medical structures [2].

Telemedicine is the use of medical information that is exchanged from one location to another via electronic communications to improve, maintain or assist patients' health [3][4]. A typical model of this telemedicine environment is presented in Fig. 1.

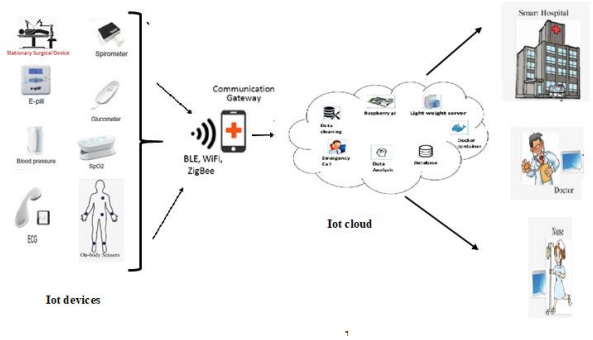


Figure 1: An IoT architecture for telemedicine practices.

A huge amount of data is constantly being produced as "big data", which requires the need for powerful tools such as cloud computing to deal with it (data exchange, sharing, management, storage, safety).[5].

With the cloud, a huge amount of data can be stored, shared and managed. Its advantages are many and varied. It's flexible: multiple users can access the data stored in the cloud online from anywhere at any time [6].

The emergence of mobile devices and cloud computing ensures a solid foundation for the development of the Internet of Things in the healthcare sector. By integrating the Internet of Things and cloud computing, health professionals can deliver faster, more efficient, and better healthcare services, a better patient experience, and less paperwork for health professionals [7].

This paper offers a survey of literature that deals with the role of the Internet of Things in the field of health care within hospitals and the role of care for many critical cases that the hospital is interested in treating, and thus can give the most important suggestions to improve this field and develop the performance of Internet of things in the field of telemedicine.

It is organized into four sections; each section has its description that explains the steps of this systematic review. Provides an introduction section, which includes a set of definitions of the terms medical internet, telemedicine, and cloud computing. The second section includes a review of a group of literature that deals with the techniques used in treating critical cases based on IoT technology in hospitals. Section III includes a discussion of the literature cited in Section Two and observations drawn from this review. The fourth and final section is the conclusions reached in this paper after reviewing the literature.

2. LITERATURE REVIEW

Human health today constitutes the mainstay of several studies and projects aimed at improving health care and achieving the foundations of the global health system. These systems provide information to patients and their physicians, including the application of IoT concepts to these systems, and increase the scalability of these systems to save unlimited lives.

The Internet of Things supports a wealth of information that can be used to make actionable decisions. In an IoT telemedicine monitoring system, a wireless monitoring network is established in hospitals by collecting physiological signals through small sensor nodes and sending them wirelessly to the user management center. The operation is convenient to make the diagnosis, and the doctors and nurses can monitor the physical logical condition of each patient in real-time through the user management platform, thus improving the doctors' work efficiency, and freeing up more time to serve patients. In addition to turning annoying medical records into electronic records, they can be uploaded and stored on the cloud for safe and more efficient archiving.

The following tables summarize a group of research that deals with the role of the Internet of Things in managing critical tasks that can be addressed within hospitals and health centers using medical devices and sensors that are subject to IoT technology and linked to cloud computing. Such as stroke patients, newborn incubators, organ transplants, etc. which are processed in real-time.

The tables give a clear visualization of each research in terms of the contribution, the tools used, and the most important advantages and disadvantages included in each research, for each of the critical cases mentioned in the following tables.

Through Table (I) we can identify the role of the Internet of Things in treating stroke patients, through the use of sensors that monitor the patient's health status, as well as monitoring their movement to avoid falls and injury. In this case, health workers are constantly informed of the patient's condition, to intervene and provide assistance in real time. The Internet of Things is also playing an auxiliary role in the rehabilitation of stroke patients with the help of a physiotherapist to improve the motor and sensory abilities that these patients have lost.

Table (II) focused on the importance of the Internet of Things in operating room management from several aspects, including Monitoring the operating room environment and controlling many parameters such as (temperature, lighting, humidity, etc.) to provide it. He. She. An appropriate atmosphere for the patient while undergoing surgery. As well as the possibility of controlling devices and equipment inside the operating room remotely to save effort and time, through continuous follow-up of more than one operating room at the same time.

The role of the Internet of Things in the management of remote surgery is shown in Table (III). Where the Internet of things is the next destination for the development of remote surgery, by providing full control of surgical devices and tools by the doctor. This opens the door to a promising technological revolution in the field of surgery.

Everyone is aware of the risks of the anesthesia phase during surgical procedures, and the sensitivity of this procedure for both the surgeon and the patient. Therefore, the Internet of Things plays a role in managing this process and assisting the anesthesiologist in monitoring the concentration of the anesthetic substance in the patient's blood throughout the surgery. So it is possible to monitor more than one patient at the same time, and receive alerts when an emergency occurs. This is what was clarified in Table (IV).

Concerning the intensive care unit, and through Table (V), the role of the Internet of things can be

highlighted the patient care within intensive care rooms, whether after critical operations or in emergency cases. Continuous monitoring of patients through devices and sensors inside the intensive care room, and the possibility of follow-up in more than one intensive care room at the same time. It is the most prominent role of the Internet of Things in this field.

Many people around the world suffer from the loss of human organs (limbs or internal organs), so these people need an organ transplant to make up for what they have lost. And because this process needs focused management, both in the area of finding organs, following up on donors, managing reservations and even during transportation and storage of organs, providing the right environment to keep the item in good condition. Table (VI) shows the role of the Internet of Things in managing this process in the most accurate way and with complete follow-up of all stages. As well as the role of the Internet of Things in monitoring the patient's condition after transplantation and monitoring the patient's vital parameters to enable the medical team to track the condition remotely.

Table (VII) gives a clear picture of the role the Internet of Things can play in managing baby incubators, through several aspects whether maintaining a balanced temperature inside the incubator, measuring the baby's oxygen and even monitoring the baby's vital data via sensors IoT s. Thus, it is possible to ensure a suitable environment for the child's development and to allow the medical staff to constantly monitor the child's condition and receive an alert in the event of any emergency.

TABLE I. **RESEARCHES FOR STROKE CASE**

Ref	Procedure	tool	Advantage	Disadvantage
[8]-2020	This work exploits virtual reality games [9-10], to improve the condition of physical rehabilitation patients with the help of data extracted from wearable sensors, allowing physical therapists to remotely monitor the patient and utilize the recorded data to improve the performance of exercises in the treatment.	1-Wearable Devices (smart gloves and headband) 2- Arduinoز 3-Bluetooth and WiFi. 4-cloud. 5-C# programming language, and Android OS.	1-This application can be used in the rehabilitation of patients with stroke and nervous disorders. 2- Low-cost devices and programs, using virtual reality games and a set of smart sensors were used. 3-Through remote monitoring, the physiotherapist were able to generate reports and record the calculated measurements via the sensors to monitor the patient's condition. 4-Personal performance of the exercises with remote monitoring by the specialist gives the rehabilitation process a personal character while reducing the period required for treatment.	The number of people who underwent the experiment was very few, only two, and even the duration of the experiment was short to determine the success and potential of the work.
[11]-2019	Designing a system for predicting stroke during sleep using the IoT enhanced by machine intelligence techniques, and by building a database of physiological data, vital signs, movement data, and electronic health records, all of which contributes to the delivery of warnings to save people.	1-PIC. 2-Sensors(Temperature, Heartbeat, BP sensor, EEG).	The successful real time stroke detection in the elderly helped send alerts with the onset of stroke and expedite the provision of medical assistance.	1-The role of machine learning algorithms is not clearly explained, and the success rates for each algorithm are not clear. 2-The networks and equipment used for the transmission are not covered.
[12]-2017	The system helps stroke patients to monitor their walking carefully with the help of a smartphone[13], and an IoT-shoe, to alert them to the possibility of falls and to avoid the injuries that may result from that.	1-pressure sensors. 2-Smartphone. 3- IoT -shoe (Arduino™ and a Wi-fly module). 4-GPS.	1- Relying on this type of modern system and exploiting the potential of the Internet of things to face the risks of falling the stroke patients [14-15], and helped to avoid injuries resulting from falls, and also helps in the speedy delivery of medical aid and reduces deaths Rate. 2-Through the Global Positioning System (GPS) within the capabilities of smartphones, the patient's location can be accessed and assistance can be provided. 3-The system does not restrict the movement of the patient because it is located in a wearable part, which is the shoe, which provides comfort in use.	1-Memory and account limitations are among the most obstacles to work and can be improved by using more advanced processors and hardware programs. 2-There is no complete explanation for how long it takes between one reading to another, as this affects the patient's monitoring and follow-up. Also, the number of experiments conducted on the system is very small.

[16]-2017	The proposed work for monitoring stroke patients has been harnessed by combining Internet of Things (IoT) technologies and machine learning to achieve an accurate and fast diagnosis and by leveraging data collected from the sensors used so that healthcare workers can provide timely assistance to save the patient's life.	1-Arduino Mega. 2-sensors (Pressure, Heartbeat, and Sugar sensors). 3-Wi-Fi module. 4-Web Application. 5-Cloud Server.	1-The process of collecting data via sensors and thus analyzing this data with the help of machine learning techniques helped decision-makers make the correct prediction [17], and take appropriate measures. 2-The accuracy in analyzing the data obtained using the ensemble method of tree based Classification-Random Forest [18], gives them the incentive to use this method to diagnose other types of diseases. 3-Through the use of the web application and cloud, patient records were stored and alerts were sent to the doctor's mobile in the event of a critical condition discovered, and the doctor could also refer to the patient's previously recorded data.	1-Although the cloud is used to store data, the protocols used to transmit data were not covered during the research. 2-It was possible to include other types of sensors to help stroke patients overcome the risks that they would be exposed to during a stroke, such as the motion sensor.

TABLE II. **RESEARCHES FOR MANAGEMENT OF THE OPERATING ROOM**

[19]-2021	This work presented a new way to manage two operating rooms in terms of creating the right environment to conduct operations. Through the application, the doctor was able to monitor the temperature and humidity of the room and control it in a manner appropriate to the operation. In the event of any problem, the doctor informs the nurse or the responsible employee to avoid the defect, and all this is done by engaging the cloud to store data in addition to focusing on the security aspect to allow access to both web and mobile applications.	1-Sensors (temperature ("Dht11"[20]) and humidity). 2-Raspberry card [21]. 3-web application. 4-Robot equipped with humidity and temperature sensors. 5-Arduino board. 6-Cloud layer based on Ubidots [22], 7-6LowPan protocol [23]. 8-Java JEE language.	1-The accuracy of this work comes from providing all the components of a successful operations room management, from close monitoring and a focus on authentication and authorization to accessing the web and mobile applications. 2-The system takes into account the malfunctions that the sensors may encounter in the operating room while using the robot as an alternative to ensure the continuity of work and reduce errors.	The work was limited to monitoring the temperature and humidity in the operating room, and it was better to take into account other aspects such as the percentage of microbial contamination because it may pose a threat to the patient's life.

[24]-2020	The system proposes an operating room with automated processing via the Internet with the help of a processor (ARM7) and the Internet of Things, to fully manage the room by routing commands to the machines via the Internet and from anywhere.	1- RM7 processor. 2- LED glows. 3- Relay driver. 4- C-language.	1-The work focused on the capabilities of the Internet of things to manage and operate machines via the Internet to reduce accidents resulting from human errors and give greater accuracy in following up on the drugs and services provided inside the operating room. 2-The network function visualization (NFV) [25], provides a virtual simulation of the network function and thus gives full flexibility to the Internet of things to manage the network resources 3-This work can be considered a gateway to the future of smart hospitals.	No aspect of the security and privacy of the operations room management or the security of the information circulated was covered. The protocols used to transfer the data are not covered.
[26]-2018	The work provides two possible scenarios for operating the operating room, one is Time-Critical Scenario and the other isNon-Time-Critical Scenario, through IoT structure and devices to fully control the machines and their operation through flexible control of network resources, providing a virtual simulation of network functionality NFV(Network Function Visualization).	1-RE-presentational State Transfer (REST) web. 2-sensors (lighting, cooling).	1- (RESTful) web service uses low complexity of IoT gateway, is easy to learn, and scalable. 2-The work is carried out in a university for research and learning purposes. 3-The network performance is good in terms of latency and network traffic by placing the data center near (the OPIC environment).	Using the gate for cooling and lighting separately has increased the labor cost. It was better to combine them.

TABLE III. **RESEARCHES FOR TELE-SURGERY CASE**

[27]-2020	Authors introduce the concept of tactile internet (IT) [28-29], as a modern input in remote surgery, by designing a secure authentication protocol establishing a session between the surgeon and the robotic arm, taking advantage of the advantages of elliptic curve coding (ECC) and biometrics.	1-Robotic arm. 2-Tactile internet. 3-gate away. 4-Trusted authority. 5-High Level B Specification Language (HLPSL).	1-The designed protocol has proven effective against numerous active and ineffective attacks such as offline password guessing attacks, reboot attacks, impersonation attacks, man-in-the-middle attacks, denial of service attacks, etc. 2-Search can be considered a gateway to the smart healthcare system.	Since the research mission is critical, many requirements have been put in place to ensure real time response within the network serving the business. During the research, data security was ensured without addressing the impact of this on other requirements such as reliability and latency.

[30]-2019	The research conducted a study on the possibility of recording observations about the behavior of surgical tools/forceps within laparoscopic surgery through the use of the Internet of things, which enhances safety in surgery, standardizes surgical procedures, and provides the proper use of electric irons and other devices.	1- RFID. 2-A rigid laparoscopic system [31–34]. 3-whereas an electrocautery generator.	1-The work enables automatic recording of the movement of the forceps during operation and activation of the electrosurgical probe via RFID cards and readers. 2-The work has addressed many of the obstacles that may face the transfer of control of surgical instruments to the Internet of things by linking them to a group of sensors, the most important of which is the sterilization that must be exposed to the sensors on the surgical forceps.	1-The combination of IoT and artificial intelligence with big data could have been very beneficial to improve system performance. 2-The current study had a lot of limitations and it is just a proof of concept with very small data. 3-The size of the sensors is very large and can hinder the surgery process. 4-When using these technologies in the operating room, problems may arise related to ensuring the security of information and protecting personal information. The security issues were not clarified.

TABLE IV. **RESEARCHES FOR ANESTHESIA**

[35]-2018	The online system monitors two types of undiluted narcotic drugs that are injected into human blood serum through the IoT drug monitoring system.	1-smart-phone. 2-custom-built electronic Raspberry Pi. 3-electrochemical sensing platform integrated into a fluidic system. 4-Polydimethylsiloxane (PDMS) fluidic device. 5-Cloud system. 6-Android application.	1-The research used electrochemical sensors, which are ideal for reading the rate of leakage of anesthesia dose in the amount appropriate to the patient's condition, such systems are sensitive in terms of their high ability to quickly and accurately detect the quantity of drugs. 2-Their system provides continuous care for the patient to give him/her reliable and accurate data about the patient's condition while receiving the anesthesia dose and also to provide the medical staff with the parameters at any time. 3-Using the cloud system in this research and linking it to the Internet of things gave the doctor the ability to control the patient's data and the ability to store and share it and even receive alerts for any error that might happen during the dose taking.	1-It is not explained which transmission protocols were used to deliver data to the cloud system. 2-There is no interest in the security aspect of collecting and transmitting data, even though the system deals with very critical cases.

[36]-2018	It focuses on the continuous and accurate monitoring of the concentration of anesthesia in the patient's veins through a system based on the Internet of things, and considering that effective anesthesia is achieved with the correct balance of medications intended for the patient to maintain the required level of anesthesia during the duration of the surgery.	1-Therapeutic Drug Monitoring (TDM) platform[37], (Raspberry Pi (RPi)+electrochem-ical platform+I2C communication) 2-Wi-Fi. 3-Web application. 4-smartwatch. 5-Android application (tablet). 6-Cloud platform. 7-C and C++, and Java language.	1-The proposed system interacts with any medical device that has wireless transmission capability, so it can be used to monitor other cases. 2- The fact that the system works in the cloud enabled it to monitor more than one patient at the same time and allowed the anesthesiologist to monitor up to three drugs in the patients' blood. 3-The anesthesiologist can receive alerts of critical clinical cases via a smartwatch that he wears. 4-The system guarantees privacy protection, secure storage of patient data, and the design of a procedure for obtaining patient permissions for cloud storage and remote access to data.	It would have been better to provide other communication technologies that would be ready if Wi-Fi was not available, as a precaution for the seriousness of the medical condition.

TABLE V. **RESEARCHES FOR INTENSIVE CARE**

[38]-2020	A post-operative patient needs constant follow-up to monitor his condition. This system suggests a monitoring and diagnostic unit through the Internet of Things technology, which provides the medical staff to monitor the patient remotely continuously.	1-sensors (Heart rate, respiration rate, blood pressure, oxygen saturation, and temperature). 2-Arduino UNO. 3-The cuff (sensors, Arduino UNO, and the Bluetooth module also have a battery pack to run the device for 11hrs). 4-microcontroller NodeMCU. 5-IoT cloud[39]. 6- Arduino IDE.	1-The use of such systems saves a lot of time required to follow each patient separately, as doctors can track all patients at the same time. 2-The use of the cloud gave the work the characteristic of real interaction between the medical staff and the patients in the intensive care rooms. 3-In light of the increasing need to improve health care, especially in the face of epidemics and diseases such as Covid-19, the need for such systems appears that gives accuracy in following up a large number of hospitalized patients.	There are many concerns about the provision of safety and hygiene standards for devices and sensors when used for medical purposes, due to the difficulty of sterilizing these devices.

TABLE VI. **RESEARCHES FOR ORGAN TRANSPLANT**

[40]-2018	The research is the effort of the (Safe Plant) **[**41**],** manufacturing team, which is a smart strap that is placed on the wrist of a kidney transplant patient to provide care that follows the transplant process by tracking the patient's kidneys parameters over time and it is possible to give an alert if there is any defect in the data that has been read.	1- phone. 2-Android Mobile application. 3-wrist band (body temperature, heart rate, blood pressure). 4-Microsoft Azure cloud. 5-web platform (safeplant.apareciumlabs.com).	1-Since medical care after kidney transplantation is very important for the patient's life as he is exposed to many health problems, this research was the best solution to reduce the financial and material burden of frequent hospital visits and save time through remote monitoring. 2- gave him /her the ability to track the patient's medical parameters as well as alert the user to the presence of danger through the readings gathered to take appropriate action, in addition to the presence of a "panic button" that sends a text signal to a remote medicine specialist. 3-Using (Microsoft Azure Cloud) gives the ability to store and share data with doctors.	The devices and sensors were not well studied, and the problem of the size of the blood pressure sensor appeared, so it was better to plan and confirm the specifications of the parts.
[42]-2017	The search is based on the Internet of Things system to track the transplantation process[43], starting from the purchase stage, transferring the organ and securing the appropriate conditions during the transfer, and ending with tracking the status of the patient undergoing the transplant.	1-RFID. 2-GPS. 3- smart sensor.	1-The system's reliance on the Internet of Things gave many privileges to work: a-Reducing delays in the organ procurement and distribution process. b-Tracking and monitoring the member's transportation and ensuring a safe environment for him/her. c-Monitoring the patient receiving the organ after transplantation. 2-The dependence of the work on many algorithms that perform the analysis of the data collected from the sensors has increased its efficiency.	Cloud-based server services are not optimally used, especially for proper coordination between the medical team responsible for organ transplantation and patients, in order to have access to a complete system based on the Internet of Things to make the transplant process highly efficient.
[44]-2017	The research aims to establish a human organ transplantation system based on the Internet of things to ensure speed, safety, and quality to complete the process.	1-Web page. 2-Mobile application. 3-Medical sensor. 4-Simso simulation tool.	1-Real time IoT-based organ transplantation system helps in overcoming many challenging tasks facing the completion of the operation by reducing organ distribution time and enabling laboratory equipment and resources to make the operation a success. 2-Adopting a hierarchical real-time scheduling approach to task management to ensure integration between different applications to bring the system to efficiency, speed and real time to complete this critical task[45][46][47].	1-The sensors and devices used to complete the transplant are not clear. 2-No attention has been paid to the confidentiality and integrity of personal information, either for the donors or even the recipients of these devices.

TABLE VII. **RESEARCHES FOR BABY INCUBATORS**

[48]-2020	The research aims to design a neonatal intensive care unit (NICU) with the help of the Internet of Things technology to provide the appropriate environment for the child's growth in terms of warmth and nutrition to ensure the improvement of his condition.	1-Temperature, Humidity (DHT11), Heartbeat, Respiration and breath sensors. 2-Warming component and a cooling fan. 3-Battery segment. 5-Wi-Fi. 6-Raspberry Pi. 7-LCD and Incubator. 8-Android App. 9-C language.	1-The work contains many sensors necessary to manage the incubator atmosphere, in addition to the sensors that monitor the vital parameters of the child with the ability to display them on the screen or send them to the server to follow the incubator remotely. 2-The low cost of work, as well as the use of the battery in the absence of electricity, encourages its adoption in rural areas.	1-The system lacks a lot of clarifications, including the values of temperature and humidity of the incubator and the vital parameters of the child that were monitored by the sensors as well as the life span of the supplied energy battery because the incubator needs energy permanently. 2-The system lacks dealing with the cloud and its ability to store and analyze data.
[49]-2020	In this research, the incubator is monitored remotely by monitoring temperature and humidity[50], depending on technology IoT and a set of sensors, and then sending recent reports in real time to the medical staff.	1- ESP8266 WiFi. 2-Smartphone. 3-Arduino. 4-DHT11 / DHT22 sensor. 5-LCD screen. 6- NodeMCU-v3. 7-ThingSpeak IoT App.	1-The incubator was designed at an economical and low cost to include IoT technology with smart phones. 2-Using NodeMCU-v3 as a wireless unit made work easier and gave greater accuracy than using the ESP8266 WiFi Module.	1-The work is successful and useful for monitoring, but it was supposed to include a number of sensors in addition to humidity and temperature sensors, such as heart rate and breathing sensors, because children of incubators may suffer from many problems in the heart and breathing. 2-Not linked to the cloud to store, analyze and send data alerts when necessary.
[51]-2019	The work provides an efficient and cost-effective design for incubators for newborns through the built-in device that measures certain values related to the incubator environment and others to measure the vital parameters of the child and send a message to the medical staff to follow the conditions of the incubator and ensure the safety of the child.	1-Arduino 2-Temperature and humidity sensor. 3-Light sensor. 4-Pulse sensor. 5-Wifi. 6-cloud.	1-Through the mobile phone application, it is possible to control the operation and shutdown of many of the incubator components, as well as to read indicators constantly, thus it is possible for those concerned to receive alerts in the event of an emergency. 2-Using cloud storage makes it easy to access and analyze data.	1-The effects of electromagnetic fields resulting from transmitters and devices used, which have an impact on the life of the child, were not taken into consideration. 2-The process of storing in the cloud was discussed without giving any explanation of the type of cloud or mentioning its explicit name.

[52]-2019	The system provides monitoring of the newborn incubator to follow the various standards of the incubator and the child, where the readings are constantly monitored and sent to the doctor via GSM so that the child is constantly monitored by the parents, the doctor and the nurse through the webpage via the IoT.	1-Sensors (humidity, temperature, pulse, fan, and LCD). 2-Arduino UNO. 3- Raspberry pi. 4- Wifi. with GSM. 5- Web page. 6-Camera.	The Internet of things in this work provides remote monitoring of the child by parents and medical staff, in addition to the possibility of continuous monitoring and monitoring of the registered parameters to ensure the child's safety and provide the appropriate environment for him.	1-Because the system includes dealing with the web page and the Internet in general through the IoT system, it is more appropriate to clarify the protocols used to transfer data and address the security aspect, because the child's life inside the incubator may be at risk. 2-The system did not use the cloud.
[53]-2017	The system provides a device to monitor the incubators of newborns in real time and allows early detection of the risk situation that may threaten the child's life, and ensures a safe environment for him inside the incubator.	1- LM35 sensor 2-Laptop/smart phone. 3-Sound alert. 4-Raspberry pi 2[54]/ ESP2866. 5-Web server. 6- Relay. 7- Heater. 8-Python programming.	1-The incubator is designed with low-cost, locally available components that are easy to replace. 2-The system is equipped with an application to turn on / off the devices in the incubator and issue alarms in case of emergency.	1-The system did not use the cloud, which may serve the work with high efficiency through data storage and analysis. 2-Not taking into account the effect of electromagnetic fields on children's health through the means of transmitting data and signals.

3. RESULTS AND DISCUSSION:

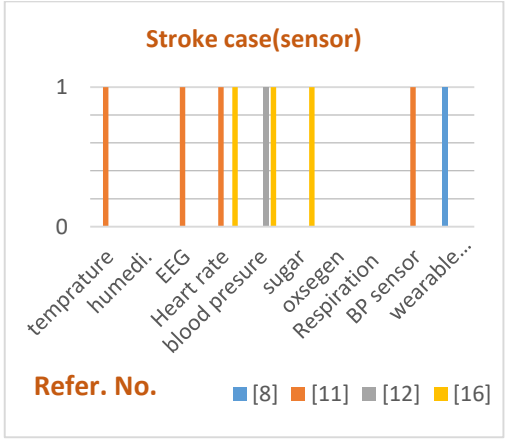
Integrating IoT technology into healthcare brings many challenges, including data storage, data management, data exchange between devices, security, privacy, and unified and comprehensive access [55].

By reviewing the literature on in-hospital critical care management based on IoT technology. Establishing an integrated framework for the success of telemedicine within health organizations is required to ensure the availability of medical services and real-time monitoring to save patients' lives.

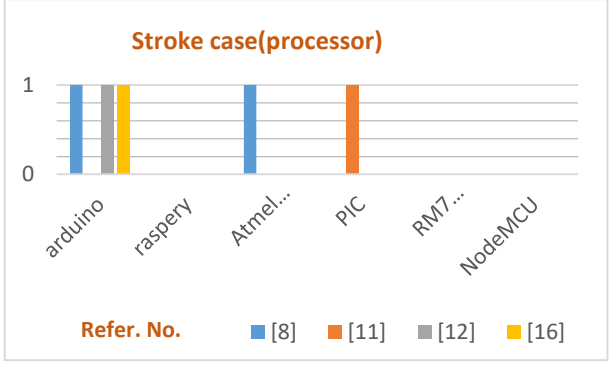
Where it can be noted some of the indicators that were evaluated for each research in terms of contributions, tools, and devices used, and the advantages and weaknesses of each of the cases mentioned in Table (I).

Regarding the first critical case in Table (I), which is the case of stroke, it can be seen that not all research depends on the cloud for data storage, analysis and sending alert signals, in addition to the lack of integration of sensors in covering all the vital factors for stroke monitoring, in addition to the lack of attention The impact of the communications and technologies used for transmission on the patient's life. As shown in Fig. 2.

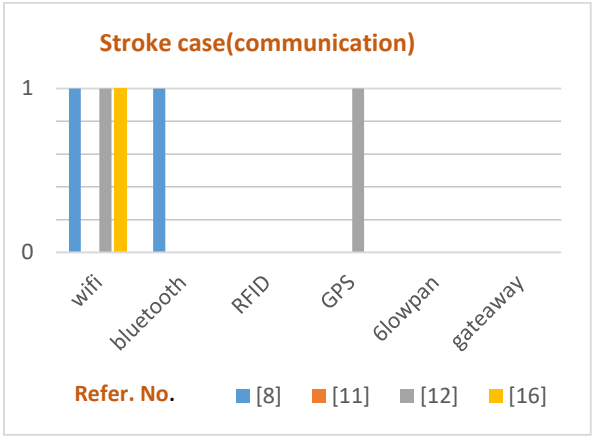
Note: for the following figures (the value of 1: represent either yes or these terms in the y-axis are mentioned in the references And vice versa for the value 0)



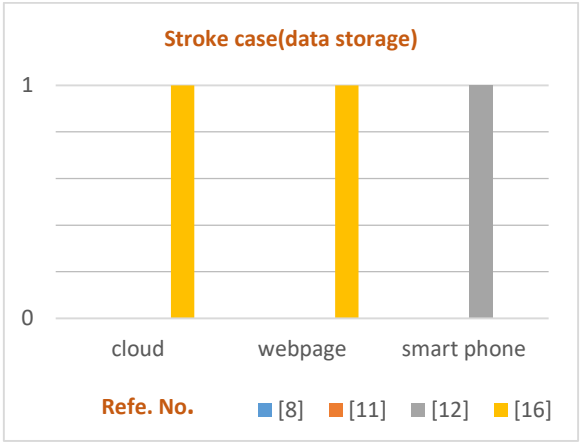
(a)



(b)



(c)



(d)

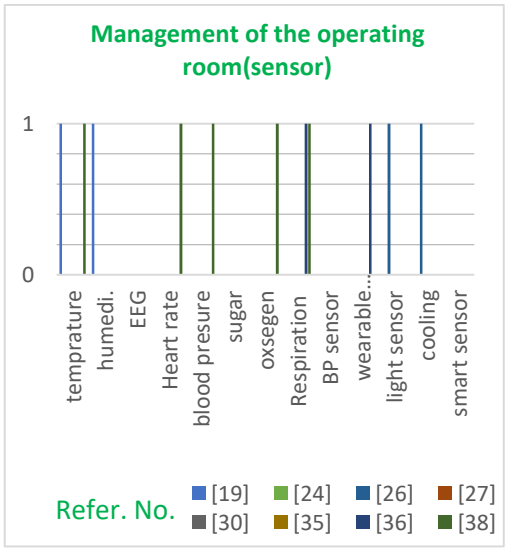
Figure 2: Stroke case: (a. sensor, b. processor, c. communication, d. data storage)

In the second case, the management of the operating room was dealt with in terms of (remote surgery, anesthesia, intensive care), and the importance of this aspect specifically and directing modern technologies for its management to provide accuracy and high efficiency, and to provide alternatives to networks and energy in the event of any failure or interruption of devices.

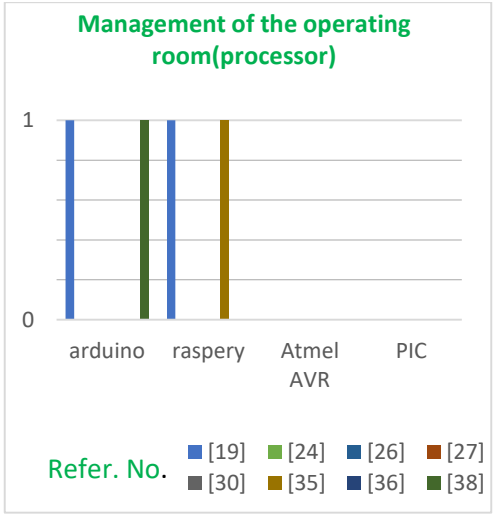
As the field of tele-surgery has recently gained the attention of healthcare researchers and developers, it is worth noting the emphasis on safety and reliability in processing data and devices and ensuring that the parties involved in the process are authenticated.

Fig.3 shows the most important sensors that were used in this aspect, in addition to the processors, communication technologies, and cloud storage in the

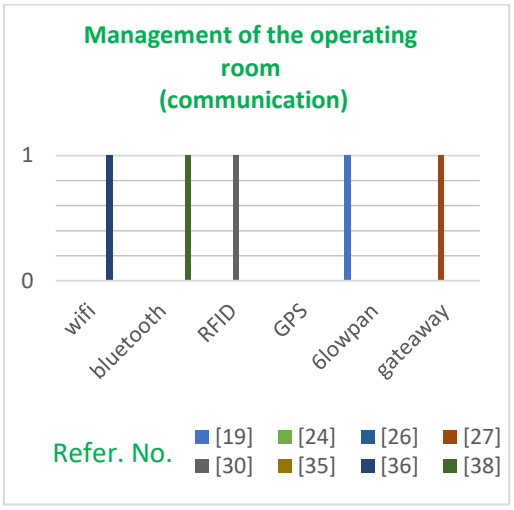
literature that dealt with the management of the operating room.



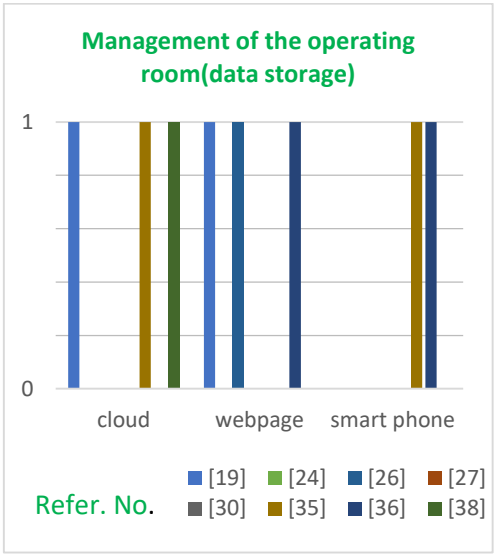
(a)



(b)



(c)

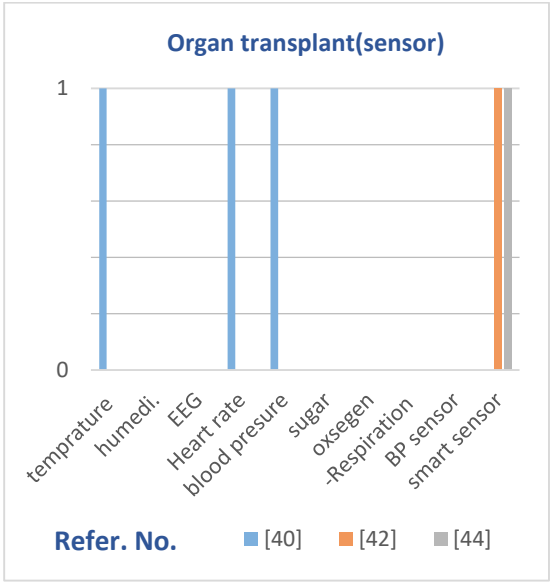


(d)

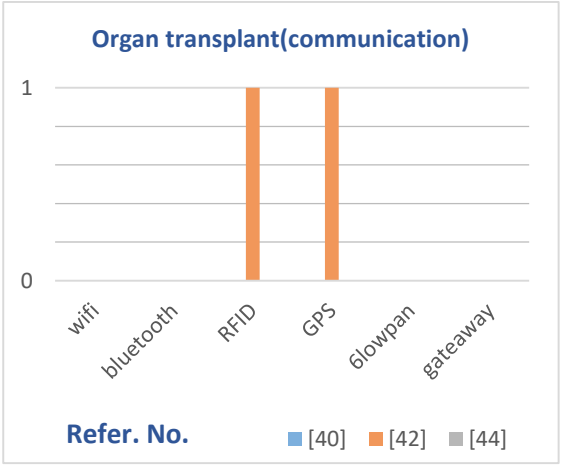
Figure 3: Management of the operating room: (a. sensor, b. processor, c. communication, d. data storage)

The issue of organ transplants gets a lot of attention in the medical field due to the large number of people who need organ transplants. The role of the Internet in managing this file begins with the method of registering and obtaining the organ, then transferring the organs and providing the appropriate conditions during the transfer and according to the requirements of each organ, during the transplant procedure and the patient after-operational monitoring, for this reason, all communication technologies must be provided along with the sensitive sensors And providing a database that is always available through cloud computing for its storage capabilities and easy access to information.

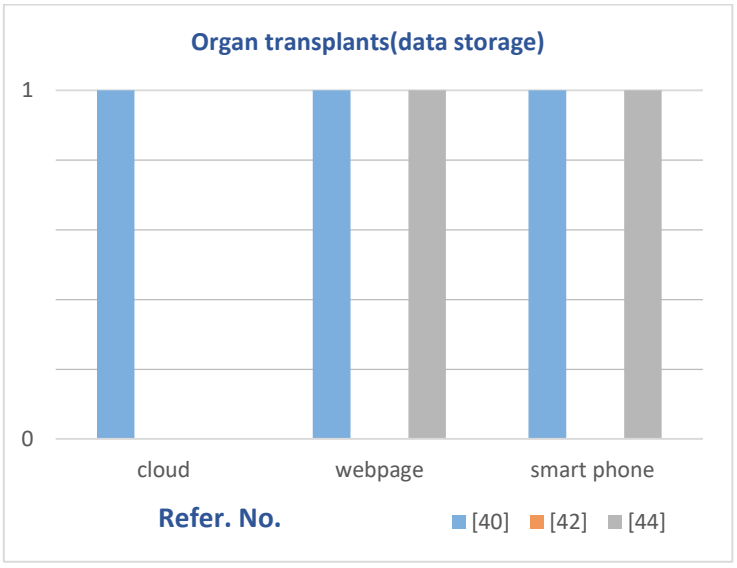
Fig. 4 shows the most important sensors that were used in the aspect of organ transplantation, in addition to the processors, communication technologies and cloud storage in the literature that dealt with the subject.



(a)



(b)

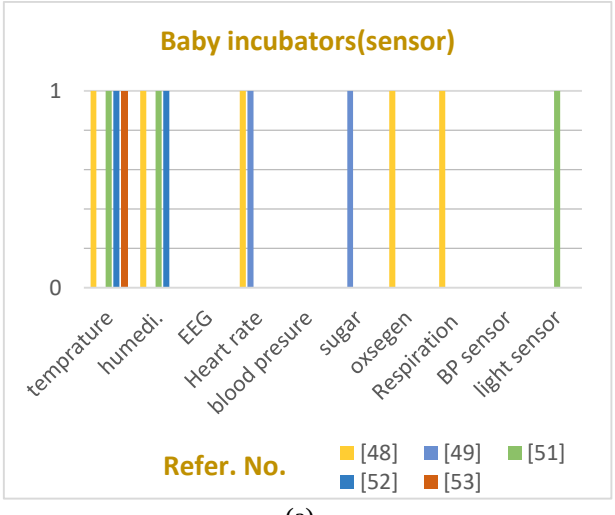


(c)

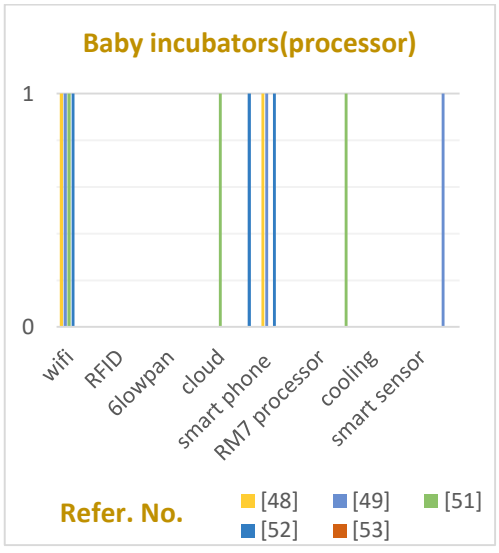
Figure 4: Organ transplants: (a. sensor, b. communication, c. data storage)

The last aspect of the table was the management of newborn incubators and the importance of providing an appropriate and safe environment for the child, as it was necessary to provide an integrated system that not only takes care of the incubator's environment in terms of temperature or humidity but integrates with recording and monitoring the vital data of the child and sending alerts to specialized staff in real-time If any errors occur.

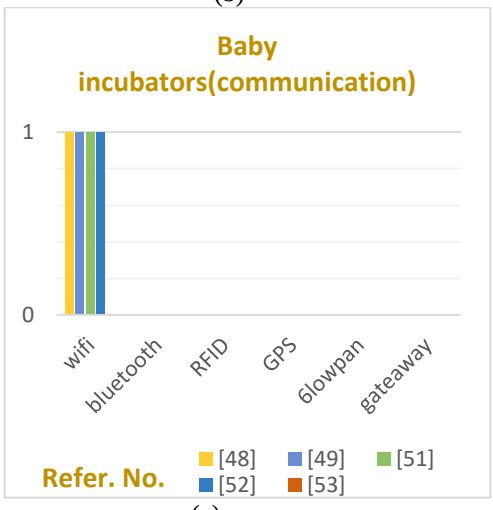
Fig. 5 shows the most important sensors that were used to take care of baby incubators, in addition to the processors, communication technologies and cloud storage, if any.



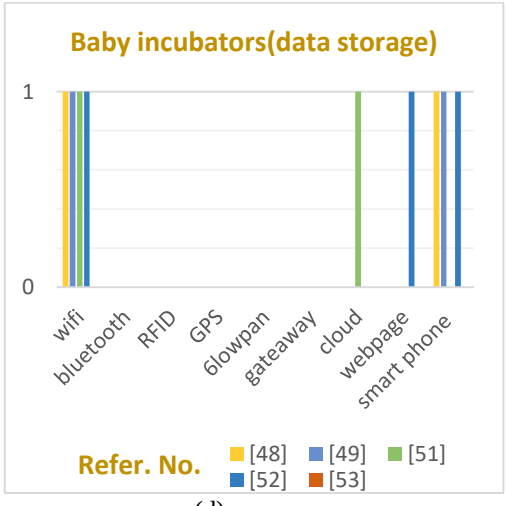
(a)



(b)



(c)



(d)

Figure 5: Baby incubators: (a. sensor, b. processor, c. communication, d. data storage)

In general, it can be said that most of the research and studies lack focus on the integration of sensors in performing the task of processing critical cases in real time, the use of cloud computing services for data storage and management to ensure safety and reliability, and the securing of patient data during transportation and storage to reach an integrated and highly efficient system.

Since critical cases require high accuracy and speed in dealing with the event whether in the intensive care room or the emergency wards, it must be ensured that the number of sensors we may need is closely related to the efficiency of the network and system in terms of traffic, speed, data integrity and vital patient parameters being transmitted and analyze it in real time.

In remote monitoring, medical professionals monitor and interpret patients' medical parameters, analyze data in real time, and provide instant feedback [55].

On the other hand, one of the main problems in times of crisis is the increase in the number of injured people who need emergency care. In such circumstances, hospitals may face various constraints such as lack of resources, hospital beds and healthcare staff. Here, the role of the Internet of Things appears in facing such emergencies and breaking many of the restrictions that stand in the way of providing the highest level of health services, especially for critical cases.

The most important aspect in hospitals is the immediate follow-up of the financial condition of the parties. Because healthcare equipment can be at risk if it is not maintained and kept safe and secure. Therefore, privacy and data security are major issues today when considering IoT devices at an organizational level or in private use.

In terms of security, the main goals of the Internet of Things are to ensure proper identity authentication mechanisms, provide confidentiality around data, etc. There are three areas of data confidentiality, in terms of security and availability as shown in Figure 6. They cause serious problems in the system, so they should be accounted for [56].

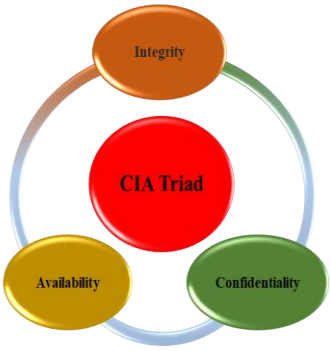


Figure 6 : The security triad

Vulnerable IoT devices can also be detected by performing passive analysis of network traffic, as it makes it easy for an attacker to capture network traffic for additional analysis of each model to know what type of devices are connected even if the traffic is encrypted.

Device fingerprinting by analyzing network traffic can also help malware passively identify vulnerable devices [57].

Due to the large number of devices that can reside within the Internet of Things, the basic requirement is to have a reliable and organized architecture to handle a large number of exchanged and shared data, this is referred to as "Big Data" which must be accomplished by sufficient storage capacity and computing power. Therefore, cloud computing provides a great opportunity to contain a huge amount of data, through the three concepts: (1) volume, which means a large amount of data; (ii) Diversity, in the sense of heterogeneity of data; (3) The speed has to be changed due to the rate of data production [57].

The process of managing sensors, collecting data from them, and then storing them in the cloud depends on a very important factor, which is the rate of energy consumption within the IoT infrastructure, and finding alternatives to the energy that the devices need to function, especially those that need to interact in real time and related to people's lives. So we see a big trend to check the amount of energy consumed and find ways to get continuous energy from the sensor surroundings to ensure accuracy of work and provide the right structure that meets the need for the Internet of things in various areas of life.

Table (VIII) shows the body of literature covered in this research and the extent to which important aspects related to telemedicine cover critical cases in terms of: real time, security, and network traffic, as well as dealing with a huge amount of data related to vital patient parameters. Fig. 7 gives an outline of the points mentioned in the table.

Across the 20 sheets listed in Table 8, the focus on every aspect of real-time and energy consumption was at 0.65, followed by big data at 0.5, while the remaining focus was on traffic and security. in percentage 0.36 and 0.1, respectively. Through these percentages, we note the lack of interest in the issue of security, which is the new trend of many recent research and studies, due to the increasing attacks on these technologies and devices that work on the principle of the IoT, which may lead to disruption and disruption or obtaining wrong results and data from those devices. So it is better to give importance to the issue of security, by providing authentication to the people who control those devices and keeping the data coming from them, and transferring it securely by monitoring the movement of that data from the source to the downstream, to provide the reliability that gives any system protection from many attacks.

TABLE VIII. THE BASIC ELEMENTS OF THE RESEARCH TOPICS PRESENTED

Ref. No.	Real-time	Security	Traffic	Big data	Energy consumption
[8]	True	False	False	True	True
[11]	True	False	False	False	False
[12]	True	False	False	False	True
[16]	False	False	False	True	False
[19]	False	True	True	True	True
[24]	True	False	True	True	True
[26]	True	False	True	True	False
[27]	True	True	False	False	False
[30]	False	False	True	False	True
[35]	True	False	False	False	True
[36]	True	False	True	True	True
[38]	True	False	False	True	True
[40]	False	False	False	True	False
[42]	True	False	True	True	True
[44]	True	False	False	True	True
[48]	False	False	True	False	True
[49]	True	False	False	False	False
[51]	False	False	False	False	True
[52]	False	False	False	False	False
[53]	True	False	False	False	True

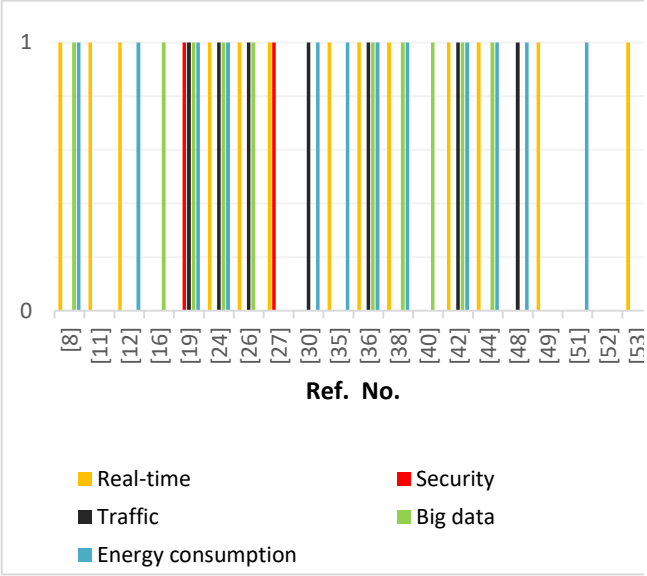


Figure 7: The outline of the points mentioned in table(5).

4. CONCLUSION

After reviewing the literature on telemedicine from within hospitals and health centers for several medical conditions. It can be said that the goal of the presented paper is to reach a modular healthcare system that integrates the Internet of Things and cloud computing to provide the ability to access shared medical data and ubiquitous infrastructure, provide services on demand, over a network, and implement processes that meet the increasing needs of time real and complete.

The study concluded that it is necessary to focus on a number of important aspects that the presented research did not take into account, which ensures the optimal performance of IoT devices. It is possible that security and privacy issues are the only obstacle standing in the way of the development of IoT devices through the vulnerabilities that may be exposed to them once they are connected to the Internet and the sensitivity of the information circulated through these devices. Therefore, security means and means should be used to ensure the security of patient information and prevent unauthorized access to devices within the hospital. Also, the flow of data and signals within the network is critical to maintaining the quality of services and covering the huge amount of data being shared with the least amount of energy consumed. All this contributes to a more efficient network and ensures access to real-time data for specialists within the hospital so that they can handle critical cases with high accuracy. Upon achieving the efficiency of each of the mentioned elements of the Internet of Things, shortly we will be able to reach the establishment of smart hospitals with high precision services in real time.

REFERENCE:

[1] M. Mirjana, et al ,"A custom Internet of Things healthcare system," 10th iberian conference on information systems and technologies (CISTI). IEEE, 2015.

[2] M. Princy, et al ,"A cloud computing based telemedicine service," 2013 IEEE Point-of-Care Healthcare Technologies (PHT). IEEE, 2013.

[3] L. Kirill, "Internet of Things for personal healthcare.: Study of eHealth sector. Smart wearable design," Mikkelin ammattikorkeakoulu, 2016.

[4] R. Carlos, et al., "A cloud computing solution for patient's data collection in health care institutions," 2010 Second International Conference on eHealth, Telemedicine, and Social Medicine. IEEE, 2010.

[5] T. Danan, et al. ,"A platform for secure monitoring and sharing of generic health data in the Cloud," Future Generation Computer Systems, 2014.

[6] T. Nadia, " IoT and Telemedicine in anesthesia practices enabled by an Android application with cloud integration," Diss. Politecnico di Torino, 2018.

[7] L. Minh Dang, et al., "A survey on internet of things and cloud computing for healthcare," Electronics 8.7, 2019.

[8] P. Octavian, et al., "Remote monitoring of physical rehabilitation of stroke patients using IoT and virtual reality," IEEE Journal on Selected Areas in Communications 39.2, 2020.

[9] T. Suradej, and Jarugool Tretriluxana. "Differential effects of feedback in the virtual reality environment for arm rehabilitation after stroke," 2015 8th Biomedical Engineering International Conference (BMEiCON). IEEE, 2015.

[10] L. BOR-SHING, et al., "Novel upper-limb rehabilitation system based on attention technology for post-stroke patients: A preliminary study," IEEE Access 6, 2017.

[11] S. Monisha , et al., "IoT based earlier stroke prediction," International Journal of Innovative Research in Advanced Engineering (IJIRAE), Volume 6 ,March ,2019.

[12] M. AKM, et al., "A wireless IoT system towards gait detection in stroke patients," 2017 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops), IEEE, 2017.

[13] A., Majd, et al., "A smart and passive floor-vibration based fall detector for elderly," 2006 2nd International Conference on Information & Communication Technologies. Vol. 1. IEEE, 2006.

[14] W. Vivian, et al., "Falls in individuals with stroke," Journal of Rehabilitation Research & Development, Volume 45, Number 8, 2008.

[15] B. Yaron, et al., "Gait characteristics of elderly people with a history of falls: a dynamic approach," Physical Therapy . Volume 86. Number 11 . November 2006.

[16] R. Ani., et al. ,"IoT based patient monitoring and diagnostic prediction tool using ensemble classifier." 2017 International Conference on Advances in Computing, Communications and Informatics (ICACCI). IEEE, 2017.

[17] CH. Iuliana, et al. , "An approach of a decision support and home monitoring system for patients with neurological disorders using internet of things concepts," WSEAS Transactions on Systems, 2014.

[18] R. Ani, et al., "Decision support system for diagnosis and prediction of chronic renal failure using random subspace classification," 2016 International Conference on Advances in Computing, Communications and Informatics (ICACCI). IEEE, 2016.

[19] K. Moez, et al. ,"A formal testing model for operating room control system using internet of things," Computers, Materials & Continua (CMC), vol.66, 2021.

[20] Ni. Tianlong, "Application of single bus sensor dht11 in temperature humidity measure and control system [J]," Microcontrollers & Embedded Systems 6, 2010.

[21] K. Dennis, " Pi home automation with Arduino, "second edition, Packt Publishing, 2013.

[22] E. Liliana, et al. ,"Interface with Ubidots for a fire alarm system using WiFi," 2018 13th Iberian Conference on Information Systems and Technologies (CISTI). IEEE, 2018.

[23] Y. Nin, et al.,"6LoWPAN protocol in fixed environment: A performance assessment analysis," 2019 10th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS). Vol. 2. IEEE, 2019.

[24] K. Moez, et al.," A Formal Testing Model for Operating Room Control System Using Internet of Things," Computers, Materials and Continua, · December 2020.

[25] L. Yong, et al.,"Software-defined network function virtualization: A survey," IEEE Access 3,2015.

[26] M.Igor, et al., "NFV enabled IoT architecture for an operating room environment," 2018 IEEE 4th World Forum on Internet of Things (WF-IoT). IEEE, 2018.

[27]K. Kuljeet , et al., "Secure authentication and key agreement protocol for tactile internet-based telesurgery ecosystem," ICC 2020-2020 IEEE International Conference on Communications (ICC). IEEE, 2020.

[28] W. Xin, et al., "A QoE-driven tactile Internet architecture for smart city," IEEE Network 34.1 , 2019.

[29] A. Muhammad, et al., "Effective capacity in wireless networks: A comprehensive survey," IEEE Communications Surveys & Tutorials 21.4,2019.

[30] U. Yuki, et al., "Innovation in surgery/operating room driven by Internet of Things on medical devices," Surgical endoscopy 33.10 , 2019.

[31] C. Nicola, et al., "Laparoscopic cholecystectomy: technical compromise between French and American approach," TECNICHE CHIRURGICHE - SURGICAL TECHNIQUES, Ann. Ital. Chir., 85, 1, 2014.

[32] F. Dubois, "Laparoscopic cholecystectomy: the French technique," Operative strategies in laparoscopic surgery. Springer, Berlin, Heidelberg, 1995.

[33] K. Kelvin, et al., "Ergonomic assessment of the French and American position for laparoscopic cholecystectomy in the MIS Suite," Surgical endoscopy 28.5, 2014 .

[34] K. Kum, et al., "Randomized comparison of pulmonary function after the 'French'and 'American'techniques of laparoscopic cholecystectomy," Journal of British Surgery 83.7, 1996.

[35] S. Francesca, et al., "An IoT solution for online monitoring of anesthetics in human serum based on an integrated fluidic bioelectronic system," IEEE transactions on biomedical circuits and systems 12.5, 2018.

[36] T. Nadia, "IoT and Telemedicine in anesthesia practices enabled by an Android application with cloud integration, " Diss. Politecnico di Torino, 2018.

[37]S. Francesca, et al.,"Raspberry pi based system for portable and simultaneous monitoring of anesthetics and therapeutic compounds," 2017 New Generation of CAS (NGCAS). IEEE, 2017.

[38] H. Aravind, et al., "IOT based Wearable for Surgical and Post-Operative Patients," International Journal of Engineering Research & Technology (IJERT) ,Vol. 9 Issue 06, June-2020.

[39] U. Mohammad, et al., "Real time patient monitoring system based on Internet of Things," 2017 4th International Conference on Advances in Electrical Engineering (ICAEE). IEEE, 2017.

[40] B. Mario, et al., " Kidney Transplant aftercare with IoT Medical Wearables, " https://www.researchgate.net/publication/327653042, May 2017 .

[41] T.Girish, et al., "Dynamic clustered hierarchical real time task assignment & resource management for IoT based smart human organ transplantation system," 2017 Conference on Emerging Devices and Smart Systems (ICEDSS). IEEE, 2017.

[42] C. Benita, et al., "An intelligent organ distribution using Internet of Things-driven systems," 2017 2nd International Conference on Communication and Electronics Systems (ICCES). IEEE, 2017.

[43] B. Brech, et al., "The Interconnecting of Everything. An IBM Redbooks® Point-of-View publication by the IBM Academy of Technology," (2013).

[44] T. Girish, et al., "Dynamic clustered hierarchical real time task assignment & resource management for IoT based smart human organ transplantation system," 2017 Conference on Emerging Devices and Smart Systems (ICEDSS). IEEE, 2017.

[45] H. Oliver, et al., "Operating systems for low-end devices in the internet of things: a survey," IEEE Internet of Things Journal 3.5,2015 .

[46] N. Shah, et al., "Improvement in Quality of Care Metrics Through The Implementation of Electronic Health Records (EHR) in Renal Transplant Patient Management.: Abstract# A465," Transplantation 98, 2014 .

[47] P. Alexandros, et al., "A survey on wearable biosensor systems for health monitoring," 2008 30th Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE, 2008.

[48] K. Pravin, et al., "IoT Based Baby Incubator for Clinic," ICCCE 2019. Springer, Singapore, 2020.

[49] S. Ali, et al.,"Remote monitoring of a premature infants incubator," Indonesian Journal of Electrical Engineering and Computer Science 17.3, (2020.

[50] D. Marco, et al., "A modular sensorized mat for monitoring infant posture," Sensors 14.1,2014.

[51]S. A. Andrew, et al., "Advanced control system for syringe and infusion pump using iot," Int. J. of Innov. Res. in Adv. Eng.: IJIRAE 6.03, 2019.

[52] B. Radhika, et al., "Incubator Baby Parameter Sensing and Monitoring, " International Journal of Innovative Technology and Exploring Engineering (IJITEE), Volume-8 Issue-7, May, 2019.

[53] B. Ashish, "Temperature monitored IoT based smart incubator," 2017 International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)(I-SMAC). IEEE, 2017.

[54] K. Vasanth, et al., "Creating solutions for health through technology innovation," Texas Instruments, Dec 2014.

[55] U. Farooq, et al., "A review on internet of things (IoT)," International journal of computer applications 113.1, 2015.

[56] R. Shahid, et al., "IoT devices recognition through network traffic analysis," 2018 IEEE international conference on big data (big data). IEEE, 2018.

[57] V. Dimitrov, "Medical internet of things and big data in healthcare," Healthcare informatics research 22.3, 2016.