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# Role of Internet of Things (IoT) in Patient Health Care Monitoring and Pharmaceutical Industry

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**ABSTRACT:** IoT-based medication administration is crucial for patient care as well as for keeping an eye on the manufacturing of pharmaceuticals. Through the use of IoT, it also manages the administration of drugs to patients and therefore enhances patients' medication performance. Therefore, enhancing healthcare quality through more patient compliance, accurate and appropriate medicine dosage, and real-time monitoring. With the assistance of this technology, patient data is gathered based on crucial circumstances, transferred to the cloud, and communicated to the doctor in both digital and analogue forms via a mobile application. Using this technology, a doctor can remotely prescribe the right medication and treatment strategy for a patient admitted to the hospital or riding in an ambulance. IoT-based devices and sensors are widely employed in the pharmaceutical industry (packaging, supply chain management, equipment productivity monitoring, and quality management) and boosting production efficiency through automation in the pharmaceutical industry. This review paper discusses the value of IoT-enabled software for the pharmaceutical business and individualized medical treatment.

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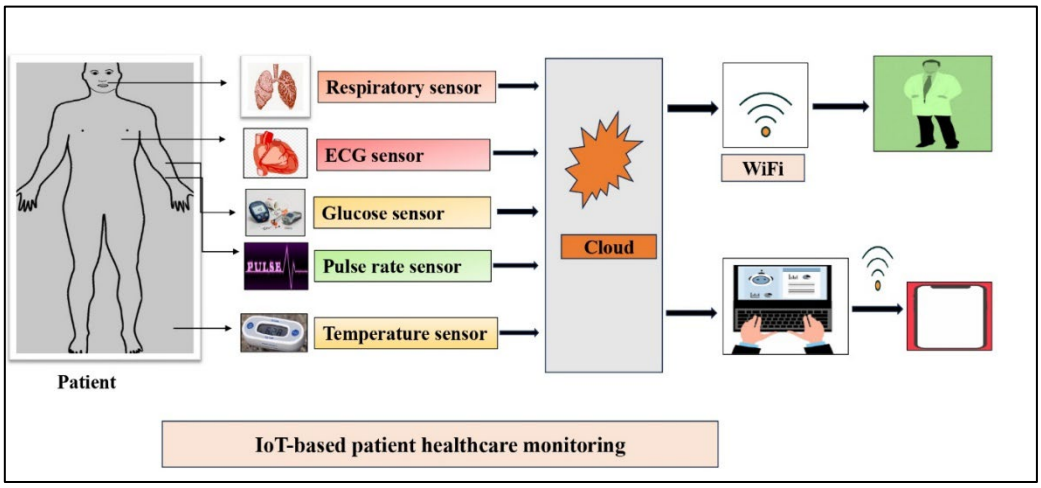


**Figure [1]:** Graphical abstract

## INTRODUCTION

Hospitalized patients benefit greatly from IoT-assisted sensors and devices, which provide automated medication distribution and allow doctors and nurses to watch patients remotely shown in Figure 2. It should include patient information, identify any risks the patient may have, and feel any changes in the body [1, 2]. Based on these risks, a treatment plan is developed with the assistance of specialists, and the appropriate medication is administered to carry out the treatment and process shown in Figure 3. It should be used for frequent diagnosis of needed disorders such as diabetes, cardiac disorders, cancer, respiratory disorders, fever, etc... [3]. Drastic appointment scheduling and remote patient monitoring are made possible by Internet of Things solutions for doctors. To lessen their reliance on medical visits and the possibility of obtaining unwarranted or improper medical care in hospitals or clinics, patients can also enhance their health at-home healthcare. Because of this, the general cost of treatment may go down while the standard of medical care and patient safety may improve. Healthcare can benefit greatly from the Internet of Things [4]. Using Internet of Things technology, a doctor can remotely prescribe an appropriate prescription and a therapy plan for a patient who is in an ambulance as illustrate in Figure 4. Soon, we'll have the option of using a health monitoring system that will allow us to check our health from the convenience of our homes and expedite hospital procedures. IoT sensors are required to be widely distributed to continuously monitor the environment and body. Progress in rehabilitation and the management of chronic diseases will be possible to be monitored thanks to this independent thinking. IoT-enabled efficient data connections from different locations will be useful for virtual consultations for remote medical treatment in the future [5]. Based on a review of the literature, researchers have created a wearable sensor that can accurately forecast a patient's health. The study concludes that treatment based on IoT yields superior outcomes than alternative approaches.

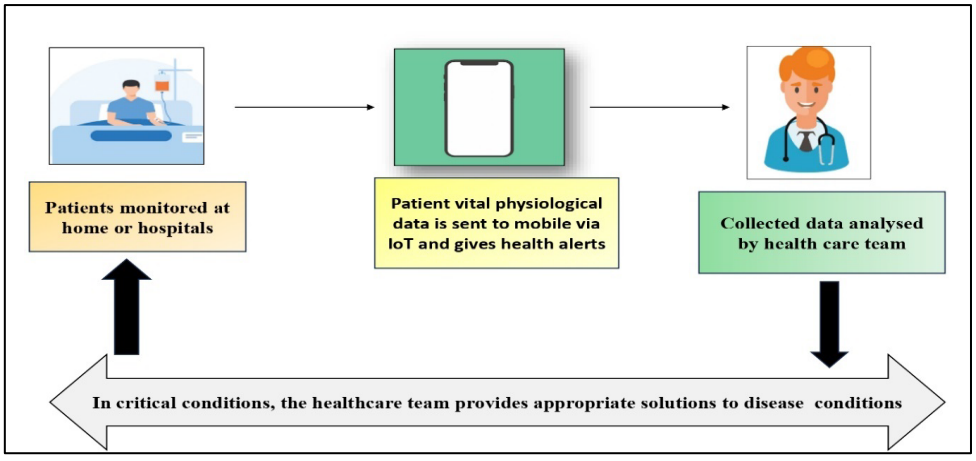


**Figure [2]:** IoT-based remote health care monitoring

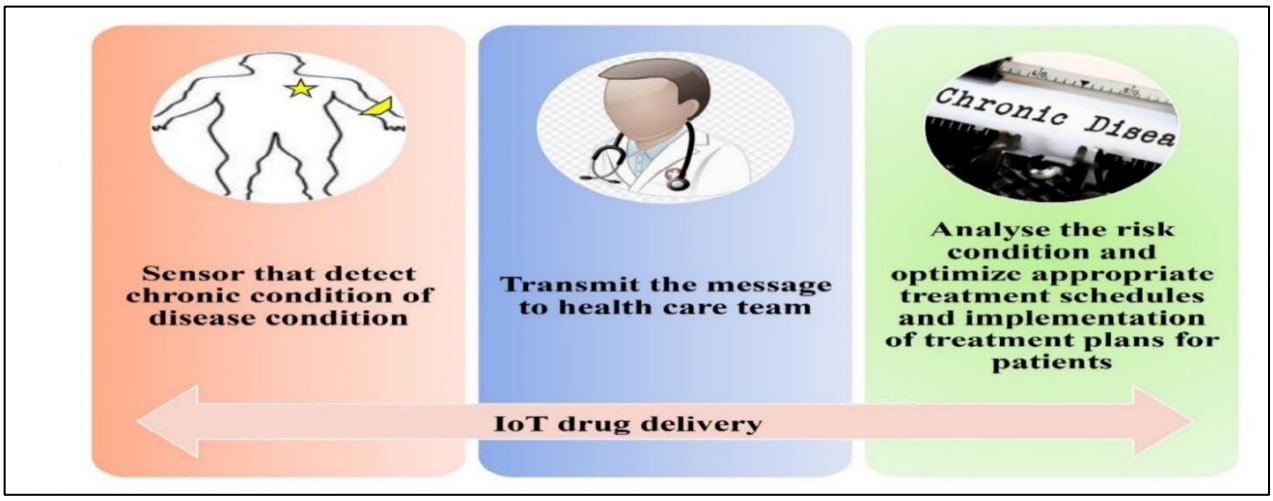


**Figure [3]:** Process of IoT-based drug delivery

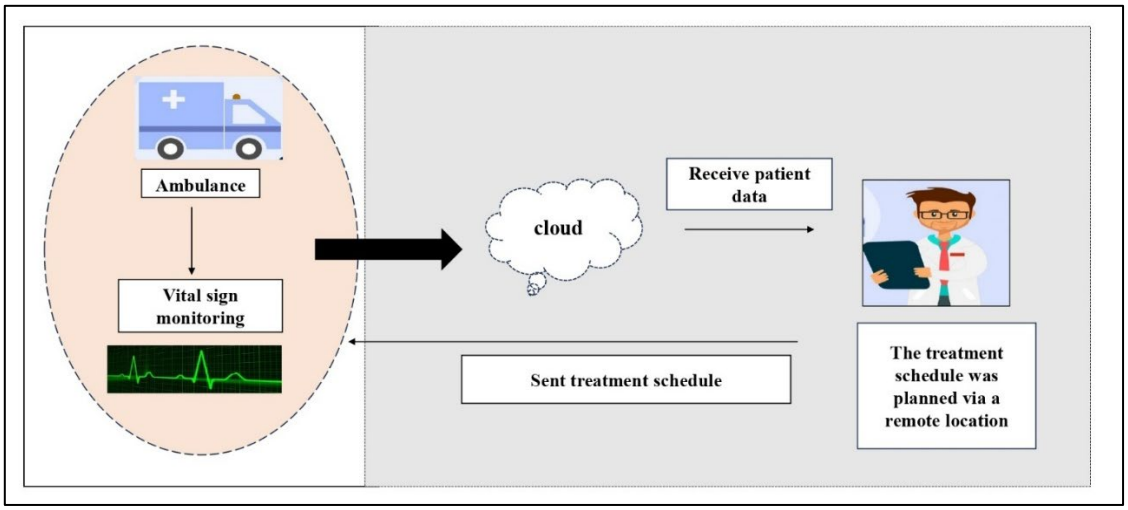


**Figure [4] :** IoT- based patient monitoring in ambulance

**Advantages**

- Enhance communication between patients and doctors
- Shorten the period of hospital stay for the patient
- Easily find out the patient's health
- IOT-enabled sensors increase medical equipment productivity
- Lighten doctor's workload
- Boost treatment effectiveness
- Avoid overdosing

**Disadvantages**

- Patient data are stored which may create a privacy issue and ethical problems.
- Cost of devices is high.

**RELATED WORKS**

Khairul et al., created the Internet of Things gadget that measures heart rate in addition to oxygen saturation and uses an appropriate sensor to calculate humidity and poor air quality as shown in Table 1. The created model effectively stores the

information gathered from patients with asthma. It includes a mobile application created with an Android app. The second one serves as the front end of a website and is separated into HTML (hypertext markup language), CSS (cascading style sheets), and Java Scripts. The backend of the website is powered by PHP or hypertext preprocessor. Seven human individuals are used in the model's testing. Based on human testing, it produces reliable findings, patients don't need to visit hospitals, and doctors provide prescriptions by mobile. Senior citizens will benefit the most from it as they won't need to travel to a diagnostic center and patients who live in rural or isolated areas should find it very helpful [6].

**Table 1:** IoT-based monitoring in asthmatic patients

| Module | Sensor | Description |
|---|---|---|
| ESP8266 (Microcontroller) [6]. | DHT11 (Temperature and humidity sensor) | Real-time monitoring of physiological parameters of asthmatic patients. |
| | MAX301000 (Pulse oximeter) | |
| | SpO2 | |
| | MQ135(Air quality sensor) | |
| | LM35( Temperature sensor) | |

Siva Kumar et al. constructed a nebulizer that uses an appropriate flow controller to adjust dosage levels under an IoT strategy as shown in Table 2. The nebulizer was created using Node MCU software and a blynk application. Nebulizers did not have a suitable way to regulate the patient's medicine supply in the past. Patients with asthma would get a predetermined dosage of medication via the suggested device. The device alerts the doctor if the patient receives a dose that is either too high or too low. With its edit feature, which allows doctors to simply adjust the dosage level, the created software contains patient data as well as device airflow and is saved in the Node MCU. Doctors get this data and use it to prepare and check the proper dose level for sophisticated patients. If a patient takes more medication than prescribed, the system notifies the doctor and patient. If neither of them responds, the system stops the nebulizer's drug administration. By adopting this approach, you can prevent overdosing and give patients the right dosage based on their age. This is because the system stores patient data and risk factors based on different age groups, as well as the dosage level and the precise moment to give the medication [7].

**Table 2:** IoT-based monitoring in pulmonary disorder using nebulizer

| Module | Sensor | Description |
|---|---|---|
| NODEMCU [7] | Nebulizer( Air flow and dose-measuring sensor) | Controlling the drug delivery in nebulizers and useful for a pulmonary disorder |

Md. Obaidur Rahman et al., developed an IoT-based wearable ECG sensor to detect cardiac disorders as depicted in Table 3. The AD8232 is a tiny ship sensor that is worn on the chest that predicts cardiac activity. Predicted data is sent to the Internet of Things (IoT) via a wireless channel, and the collected data is temporarily stored in an Arduino Mega 2560. It is then uploaded to the IoT cloud using HTTP and MQTT servers, and the data is used to predict cardiac disorders using a linear regression algorithm. The ECG monitoring system plays a significant role in helping people living in rural areas identify cardiac problems with ease, thanks to the suggested model that helps patients overcome cardiac disorders based on the regularity of PQRST and the suggested approach for resolving patients meeting challenges in heart disorders [8].

**Table 3:** IoT- based monitoring in cardiac disorder using ECG sensor

| Module | Sensor | Description |
|---|---|---|
| ESP8266 [8] | AD2828322 (ECG sensor) | Detecting cardiac activity |

Anan SR et al., monitoring asthmatic patients with an IOT-based approach. They offer Internet of Things-based remote monitoring of patients' asthmatic risk by utilizing a range of sensors, such as temperature, oxygen saturation, humidity, air quality, and ECG as shown in Table 4. The technology is tested with both human participants and demo patients. It provides patients with accurate patient data, gathers information on the triggers of asthma episodes in patients, and sends that information to a physician using an Android application. In addition, it offers remote patient monitoring and aids medical teams in creating medication regimens for their patients [9].

**Table 4:** IoT- based monitoring of asthmatic risk in patients

| Module | Sensor | Description |
|---|---|---|
| NODEMCU ESP8366 [9] | MAX30100 (Sensor used to Monitor heart rate) | Monitoring the asthmatic risk condition<br>By using this monitoring system provide accurate results on testing human subjects |
| | MLX90614 (Sensor used to measure temperature) | |
| | DHT11 ( Humidity sensor for room) | |
| | MQ135 (Gas sensor to monitor air quality and used to measure ammonia, smoke, CO2, alcohol, benzene) | |
| | AD8232 (ECG signal conditioning block, Extract biopotential signal) | |

A NODEMCU and machine learning methods are developed by Amine Rahioui et al., to monitor blood glucose and body temperature in diabetic patients as depicted in Table 5. a system that uses an appropriate sensor and an Internet of Things platform to track body temperature and blood glucose levels. When the doctor receives the gathered data, he or she can more accurately diagnose diabetic patients by using the data to forecast the future. The acquired data set is classified using machine learning algorithms such as one R, SMO, Random Forest, and Naïve Bayers. The random forest method is found to be more accurate, sensitive, and precise than the other algorithms in predicting the presence of diabetic illness [10].

**Table 5:** IoT-based monitoring in diabetic patients

| Module | Sensor | Description |
|---|---|---|
| NODE MCU [10] | Glucose sensor<br>Temperature sensor | Patients with diabetes are monitored in real-time, and data is collected and sent straight to the doctor via mobile.<br>Create an insulin dosage schedule that is acceptable by using this model. Using virtual presence and critical condition physician diagnosis, diabetic patients.<br>Patients do not have the opportunity to go to the hospital. |

Khaled A. Assan et al., used an IOT platform to treat brain hypothermia utilizing a brain-cooling device. The gadget has a thermoelectric cooling element, and water circulation is the best way to cool it. Temperature is measured using an NTC

temperature sensor as shown in Table 6. The temporal artery and inner ear were fitted with a sensor. The Raspberry Pi and Arduino are parts of the system. Raspberry Pi is utilized for data visualization, and Arduino is used to handle electrical operations. MQTT was used to communicate the gathered data. The suggested solution includes Nod Red software, which makes it simple to visualize temperature data that has been acquired using the MQTT protocol. The information is then given to medical specialists who can cure brain hypothermia by using brain brain-cooling device [11].

**Table 6:** IoT-based monitoring in brain hypothermia by using brain cooling device

| **Module** | **Sensor** | **Description** |
|---|---|---|
| Brain cooling device<br>(Arduino microcontroller and Rosperry Pi) [11] | NTC temperature sensor | Helpful for monitoring and diagnosing brain hypothermia |

Nor Shahanim Mohamad Hadis et al. used the IoT technique to monitor hospitalized patients by taking their body temperature and respiration rate as shown in Table 7. The primary benefit of employing this strategy is to lessen the workload for nurses and doctors. The respiration sensor (LM35) and temperature sensor (MLX90614) are utilized to gather patient data based on age, sex, and disease state. Display the gathered data on the smartphones of the physician and nurse if the body condition is unbalanced. Using an Arduino Mega 2560, the data was sent to a health care specialist using an ESP8266 WIFI module. If the medical team uses the proposed approach correctly, patients with respiratory disorders should be able to be diagnosed more quickly [12].

**Table 7:** IoT-based monitoring in respiratory disorder

| Module | Sensor | Description |
|---|---|---|
| Arduino Mega 2560<br>ESP8266 [12] | MLX90614 (Temperature sensor) | Real-time monitoring of patients with breathing problems |
| | LM35 ( Room temperature sensor) | |
| | LM35 ( Breathing temperature sensor) | |

An U1terius 501 model for remote patient monitoring was developed by Naven Kumar et al., as depicted in Table 8. The created model enables the use of its sensor to determine vital signs in patients, such as heart rate, temperature, non-invasive blood pressure, electrocardiogram, and peripheral oxygen capillary saturation. The JSON (JavaScript Object Notation) format of the patient information data was collected and uploaded to the cloud. The doctor receives the gathered data directly and constructs a diagnosis protocol together. To increase treatment effectiveness through IoT, the proposed paradigm finally enables a doctor to virtually diagnose a patient inside an ambulance and provide active medication to the patient [13].

**Table 8 :** IoT- based patient monitoring in vital signs

| **Module** | **Sensor** | **Description** |
|---|---|---|
| U1terius 501[13] | ECG sensor | Monitoring patients in a remote location |
| | NIBP ( Non- Invasive Blood Pressure | |
| | SpO2 sensor | |
| | Temperature sensor | |

Parthasarathy and Vivekandan's ., design aims to diagnose and track arthritis sufferers as soon as possible. The suggested system's initial stage collects sensor data. On the second level, the data is stored in the cloud. The third level is tailored for the

collected data, which includes uric acid and edema. IOT devices can test UA (Uric Acid) and CRP (C-Reactive protein) levels in the blood quickly. By using this technique, early arthritis diagnosis is enhanced as it measures the early stages of arthritis infection [14].

A sleep apnea detector was invented by Li Haogu et al., It uses an SPO2 sensor to monitor the patient's oxygen level and HRV (heart rate variability) as shown in Table 9. The sensor's primary component is the MAX3010X proximity sensor, which connects to an ESP32 computer to function as a wireless data transmission module over WIFI. Based on tests conducted on human subjects, the developed device measures the apnea sleep situation accurately. Although polysomography is costly, it is used to diagnose sleep apnea. The disease state at the patient's home can be accurately estimated with the help of this model [15].

**Table 9 :** IoT- based patient monitoring in sleep apnea

| Module | Sensor | Description |
|---|---|---|
| Sleep apnea detector [15] | SpO2 sensor | Detecting sleep apnea stages |

**Role of IoT in the pharmaceutical industry**

The pharmaceutical industry demands a creative approach to producing high-quality products, handling everyday chores, and keeping an eye on inventory, production, and equipment management. The pharmaceutical industry faces numerous obstacles in carrying out its duties and producing high-quality products. by implementing cutting-edge, IoT-based hardware and software to solve these issues. Many companies in the pharmaceutical industry now use IoT technology to track any changes in production management, supply chain management, equipment utilization, materials usage, and other aspects that affect the production of high-quality products [16-17].

**Advantages**

- Encouraging inter-departmental communication
- Save money and time when producing high-quality goods.
- It is simple to identify both instrumental and human error in the pharmaceutical industry during product manufacturing.
- Pharmaceutical products delivered successfully depending on technological and equipment performance
- Decrease both instrumental and batch failures
- Perpetual production of goods in batches

**Disadvantages**

- IoT technology that raises privacy and security concerns in the pharmaceutical industry
- Insufficient standardization procedure
- IoT technology requires a skilled operator.

**Application of IoT in the pharma industry**

- **Material management**
- **Quality control**
- **Equipment maintenance**
- **Manufacturing**
- **Clinical trials**

**Material management**

IoT sensors can be used to track the position, motion, and status of inventory items. The collected data is stored on the cloud, notifying users of any changes that occur to the inventory items. This facilitates the management of the supply chain in the manufacturing sector of the pharmaceutical business. Pharmaceutical companies can use Internet of Things (IoT) devices to gather information from warehouses and industrial facilities on production, transport, and even material receipt. Not only can this data assist with recalls by quickly locating and removing faulty products from the supply chain, but it can also reduce the possibility of excessive stock or inadequate stocking [18].

**Quality control**

pharma manufacturing with IoT devices is that it makes quality control possible through production. IoT sensors track every single item in great detail, including how it fits into a formula, as they keep an eye on the manufacturing environment on the factory floor, Important parameters including temperature, humidity, gas exposure, and radiation emission are tracked by the sensors [19].

**Equipment maintenance**

The Internet of Things is utilized by the device to verify that the equipment is operating as intended. Sensors and other devices collect data about the state of the equipment to find any issues that may need to be addressed to prevent future malfunctions [20].

**Manufacturing**

The pharmaceutical business uses the IOT technology to monitor routine processes. Sensors are installed in the production area to automate routine tasks and to monitor various aspects such as raw material shortages, equipment malfunctions, environmental conditions, storage conditions, etc…To boost manufacturing productivity, the device used the IoT platform to send a message if a problem arose in the production area [21].

**Clinical trials**

Real-time data collection enabled by IoT technology streamlines clinical trial procedures, shortens research timeframes for novel medicines and diagnostic techniques, and enhances clinical trial execution. Clinical researchers' first impressions based on patient experiences are encouraging when it comes to gathering biometric data from trial participants using more effective data collection devices. By connecting to the internet, these devices can enhance wireless transmission to other machines and assist in gathering data for analyses [22].

## CONCLUSION

Cloud computing ports are utilized in the Internet of Things integrated health care monitoring to enable remote patient monitoring. In real-time, it records and conveys physiological data from the patient. Medical practitioners can use the tool to assess severe diseases, administer drugs, and determine dosages. The device deployed in the ambulance enables a physician to virtually see a patient inside an ambulance to diagnose chronic illnesses at critical times and helps pharmaceutical workers organize their daily schedules in a way that will enhance their comprehension of drugs and active ingredients. The Internet of Things has proven advantageous for pharmaceutical companies as a whole.

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