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A REVIEW ON SMART DRUG DELIVERY SYSTEM BASED ON INTERNET OF THINGS

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ABSTRACT

Now a day's smart drug delivery systems rely heavily on the internet of things (IoT). It is an emerging field with prospective possibilities for enhancing drug therapy effectiveness, safety, and patient compliance. IoT-based drugs delivery systems utilize smart tools, innovative gadgets, and sophisticated sensors to track and analyse patient health measures in real time, enabling targeted and personalized drug delivery. Numerous gadgets, including wearable and implantable types like inhalers, smart pens, auto-injectors, and infusion pumps, are used to execute this technology. IoT-based drugs delivery systems however, provide a number of obstacles, including assuring data confidentiality and privacy, regulatory compliance, compatibility, and accuracy. It also emphasizes the difficulties in ensuring the effective and safe implementation of this technology in healthcare facilities. Sustainability is now a major concern for the public, as the rapid advancement of IoT technologies offers a variety of beneficial advantages. However, in order to minimize adverse impacts and make sure proper utilization of the worldlimited assets, this rapid development needs to be carefully monitored and assessed from an environmental perspective. The review of article primary findings is improved comprehension of the state of technology advancement in IoT applications.

KEYWORDS: Healthcare IoT; internet of things; wireless drug delivery; wearable smart drug delivery devices; wireless body area network (WBANs); machine learning (ML); sensors.

INTRODUCTION

A drug delivery system is the process and pathway that a medication takes to reach the location in the body where it will work to demonstrate the effectiveness of its treatment. To maximize medicine distribution and disease detection. Smart drug delivery is a cutting-edge strategy that optimizes drug efficacy, safety, and patient compliance by combining cutting-edge hardware, sophisticated software, and sensors into drug delivery systems. These systems are specifically designed to autonomously release medication according to a patient condition, reducing human error and guaranteeing the best dosage at the appropriate moment. By keeping track of the patient health, makes personalized treatment possible by enabling customized drug release and dosage. Medication can be improved smart drug delivery systems.[1] IoT technology enables control over the many mechanisms by which health care duties are carried out over Internet.[2,3] The Internet of Things, or IoT, is "a dynamic global network framework with self-configuring capacities based on standardized and compatible protocols for communication where both real and virtual things have identities"[4] With the advancement of technology in society, new options have emerged that hold an opportunity to ease our daily lives and deliver more efficient services or industrial processes. Digitalization has enabled "smart" to become the epicenter of continuing technological developments. In fact, IoT technologies are now widely regarded as one of the fundamental pillars of the fourth industrial revolution, owing to their great potential for innovation and meaningful benefits to society. However, every development uses a finite amount of resources and leaves behind a different environmental footprint, particularly with respects to the types of pollutants that are used. Technologies based on the Internet of Things (IoT) offer a whole new way of looking at how many fields, like engineering, agriculture, medicine, and other unknown areas, can advance.[5,6] Drug delivery is the technique of providing a pharmaceutical molecule to achieve a therapeutic impact in the prevention of disease using medications and it ranks among the most important modalities of medical treatment together with surgery, radiation, physical treatment, and psychotherapy. Such treatments have serious adverse effects such repeated treatments, altered biodistribution of medicines, and the acquisition of multidrug resistance (MDR) by the cells. It involves the administration of a pharmaceutical compound to produce a therapeutic impact in the prevention of disease by medications.[7]

The following crucial elements have a significant impact on the growth of particular IoT application areas:

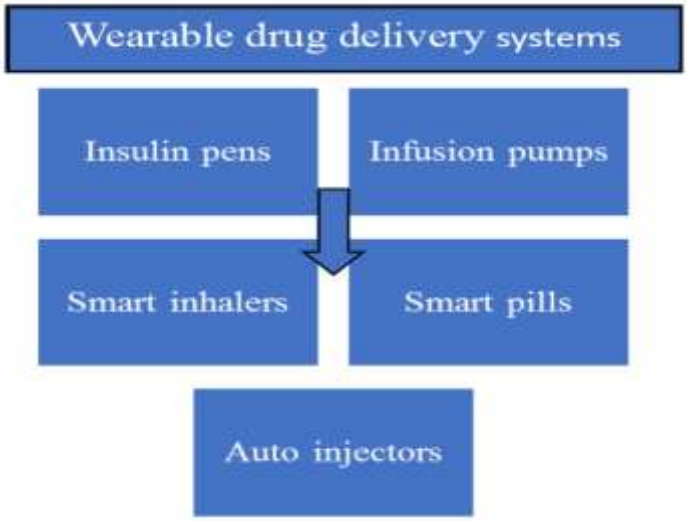
- Improvements in electronic components that are generally accessible.

- Availability of software solutions and an environment that is easy to utilize.
- Solutions for sensor technologies and data gathering,
- Adequate energy supply for the manufacture and operation of Internet of Things devices, as well as network quality, including infrastructure and connectivity.[5,6]

Types

➢ **Wearable drug delivery systems**

Innovative healthcare solutions that use technology to increase delivery efficiency and accuracy are wearable drug delivery devices based on the Internet of Things. Health gadgets, such as patches or wristbands, are worn on the body to monitor vital signs and, using the information collected, provide medication. Patients with chronic diseases benefit from the devices' guidance with drug adherence, which lowers the possibility of adverse outcomes.[1]



1. Insulin pens

Smart insulin pens are computerized, linked insulin pens that accomplish more than just remember information. They can automatically send information to the user's mobile device regarding the time and amount of insulin provided, remind them to take their insulin, and assist with bolus calculation. Bluetooth® technology is used to wirelessly send the clinical data from the smart insulin pen to a smart phone application (app). Smart insulin pens may help reduce glucose fluctuation and enhance glycemic control. From the first-generation insulin pens to the most recent smart insulin pens, we will examine the development of insulin pens over the past few decades in this overview.[7] Refer table no.1.[1]

Table no. 1

Brand name	Name	Key features	Limitations
Cmpanion medical	InPen	Insulin dose calculation with integrative diabetes management app	Cost, incompatible with search as U-200 humalog-, Toujeo-, or Tresiba-type insulin, limited data sharing, and device dependency.
Novo Nordisk	NovoPen® 6 and NovoPen Echo® Plus	Insulin dose calculation with integrative diabetes management app	Compatibility: Novo Nordisk's insulin products, including NovoRapid, Levemir, and Tresiba. No dose memory and no automatic dose calculations.

2. Infusion pumps

Hospitals frequently use pump exploitation to deliver vital fluids, including dangerous drugs. The infusion pump, which manages and regulates fluid administration, is used to administer medications throughout treatment. There are several types of infusion pumps available, such as patient-controlled analgesia systems, big capacity pumps, and ambulatory pumps. infusion pump that uses Internet of Things-based monitoring and control platforms to give patients and physicians remote monitoring and control capabilities. The main objective is to replace and remove power-hungry parts from the current system and turn it into an Internet of Things gadget that can be watched over and managed using an Android smartphone while minimizing costs and power usage.[8] Refer table no.2.[1]

Table no. 2

Brand name	Name	Key features	Drug delivered	Limitations
Tandem Diabetes Care	t: slim X2 Insulin Pump	Wearable insulin pump with touchscreen interface and Bluetooth connectivity.	Insulin	Device recharging required, infection risk, malfunctions.
Insulet	Omnipod DASH® Insulin Management System	Wireless pump with handheld controller, customizable insulin delivery, waterproof for 72 h.	Insulin	Training required, frequent pod changes.

3. Smart inhalers

The Smart Inhaler, the main objective is to help the person manage their asthma as much as possible while continuing to live as symptom-free as feasible. People who use this smart inhaler will live better, more efficient lives. Additionally, it is critical that the person learns to recognize early signs of improvement, permit appropriate risk assessments, and know when to modify the medication items in the event of an exacerbation. People will be more cautious and aware when our smartphone app alerts them to changes in their body's state and their surroundings as they get more knowledge about the symptoms of asthma attacks.[9]

4. Smart pills

A Smart Pill Expert System based on IoT is a well-organized, safe, and effective pill dispensing expert system designed to help and assist all people and institutions. It also manages expenses and makes sure that patients and users adhere to their prescriptions within the allotted time. By ensuring that the right patient takes the right medication at the right time, the system, equipped with the right sensors, lowers the financial cost of non-adherence while simultaneously delivering timely and effective treatment.[10] IoT in healthcare using SPEC 2.0, an enhanced smart pill expert system.

The system aims to precisely deliver the prescribed dosage of medication at the scheduled time. One of SPEC 2.0's most notable characteristics is its accessible user interface which makes using any smart drug delivery simple for users of all ages. This system's primary goal is to provide control and monitoring features through an Android application without the need for in-app purchases or subscriptions. The Android application has many capabilities, such as the ability to send SMS messages and warnings about the distribution of pills. Using this tool, users can stay on schedule.[11]

5. Auto-injectors

Auto injectors are examples of patient-operated devices that are now part of subcutaneous drug delivery systems. The demand for devices that allow people with chronic diseases to regularly self-administer drugs at home rather than visiting a clinic is what is driving this innovation. Due to their ease of use, convenient and user-friendly autoinjectors are a top priority. The market for autoinjectors is expected to grow significantly, driven by a number of factors, including the rising need for home care as a result of the rise in the prevalence of chronic illnesses. Easy-to-use autoinjectors may help people feel less anxious about needle

fear, mishaps, and mistakes. Work on human factors development is essential because improved usability can boost patient safety, acceptance.[12]

Applications

- IoT technology is used by smart insulin pens to monitor and control insulin dosage for diabetics.
- By preventing disruption to the infusion site, wearable infusion pumps reduce the risk of infection while providing a mobile and easy way to provide medicine.
- One kind of wearable smart medication delivery device that helps people with respiratory conditions like asthma and COPD better control their symptoms is the smart inhaler.
- Medical devices that may be programmed to automatically provide a predetermined dosage of medication are known as smart auto-injectors.
- These gadgets use Internet of Things technology to monitor and regulate drug distribution in real time, increasing the procedure' precision and effectiveness.
- Drugs like chemotherapy or painkillers can be delivered straight to the site of action via implanted infusion pumps.
- Used in treatment of cancer.[13]
- Savings: The expense of in-person visits can be reduced by meeting and evaluating patients remotely. Moreover, a large number of patients can now be hospitalized and closely watched at home because to the development of home care equipment.
- Outcomes of therapy: the treatment procedures were completed accurately since all data is stored in the cloud and sent to the doctor on a regular basis due to the consistent, continuous, and automated monitoring. By using this approach, it is possible to guarantee that medical attention is given as quickly as possible in order to assess the healing process.
- Disease management: illnesses can be identified and treated before they worsen if a person's health indicators are regularly tracked and reported.
- Error reduction: The rate of medical errors and the critical and financial expenses that go along with them can be considerably decreased by using accurate and thorough data that has been collected automatically and free from human oversight
- Patient satisfaction: the patient benefits from a number of factors, including the focus on the patient's needs, accurate data, prompt treatment, lower costs, fewer follow-up visits,

documentation of the recovery process, and above all the patient's active involvement in the course of treatment.

- Medication management: IoT helps individuals take medications as directed and helps pharmacies and medical facilities avoid wasting pharmaceuticals.[14]

Challenges

- Data security: To avoid unauthorized access and data compromises, strong security measures need to be in place.
- Regulatory standards: To ensure patient safety and effectiveness, strict regulatory standards must be fulfilled.
- Implications for ethics and society: in order to be in line with societal values and objectives, ethical and social issues need to be discussed.
- Device accuracy and dependability: To guarantee patient safety and treatment efficacy, IoT devices need to be precise and dependable.
- Standardization and compatibility: These are essential for smooth communication and cooperation between platforms, sensors, and devices.
- Limited connectivity: Low latency must be taken into account in healthcare since limited connectivity might have disastrous patient consequences. High adoption costs: For organizations seeking to enter this industry, the high costs of development, manufacture, and adoption pose a significant financial obstacle.
- IT departments with inadequate training: During implementation, IT departments may find it difficult to handle safety, security, and maintenance when faced with a significant flood of IoT devices.[1]

CONCLUSION

The drawbacks of conventional drug administration techniques may be addressed by smart drug delivery systems.[15] IoT-enabled smart devices have begun to help healthcare providers, such as physicians, hospitals, and clinics, provide care and precise treatment services and methods. With the use of IoT-enabled devices and integrated apps, patients may use these devices from any location and instantly communicate their medical conditions and test results, making it simpler to incorporate testing into daily life. The entire patient care workflow can be automated with the usage of IoT technologies. This system alters the way the hospital pharmacy used to operate, using Internet of Things technology to identify

medications automatically, organizes the distribution and storage of drugs, and lowers the error rate of artificial drug distribution.[3]

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