Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 14s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Iot-Based Smart Medicine Dispenser: A Technological Solution for Medication

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Cite this paper as: Abhijith M, Aadith S, Anshu Kumari Gond, Krishna G, Dhanasri G, Bhavani, Dr. K. Selvavinayaki, (2025) Iot-Based Smart Medicine Dispenser: A Technological Solution for Medication. *Journal of Neonatal Surgery*, 14 (14s) 206-211.

ABSTRACT
Medication adherence is a significant challenge, especially among elderly and chronically ill patients. This paper presents an IoT-based Smart Medicine Dispenser (SMD) designed to automate and optimize medication management. The system incorporates an ESP32 microcontroller, Arduino, IR sensors, and a web-based interface to ensure timely and accurate medication dispensing. The integration of IoT technology enables remote monitoring, providing caregivers with real-time adherence data. The paper discusses the system's hardware and software components, implementation methodology, and potential impact on healthcare outcomes. The findings suggest that the SMD enhances medication adherence, reduces human errors, and improves patient independence...

Keywords: *IoT, Smart Medicine Dispenser, Medication Adherence, Healthcare Automation ESP32, Arduino*

1. INTRODUCTION

Medication non-adherence is a prevalent issue, leading to severe health complications and increased medical costs. Traditional methods of medication management, such as pillboxes and manual reminders, often result in missed or incorrect doses. To address these challenges, this study proposes an IoT based Smart Medicine Dispenser that automates the medication dispensing process, ensuring timely adherence and reducing human dependency.The system integrates microcontrollers, sensors, and a web-based application to provide real-time medication tracking and remote monitoring. The key objectives of this research include:

Ensuring accurate medication dispensing.

Providing automated reminders and notifications.

- Enabling remote monitoring for caregivers.
- Reducing medication-related human errors.

2. LITERATURE REVIEW

Medication adherence is a common issue, especially for elderly and chronically ill patients. Various automated dispensers have been developed to improve this, but many have limitations.

Automated Medication Dispensers

RFID-Based Systems: Track medication using RFID tags but lack remote monitoring features.

Cloud-Integrated Systems: Store data in the cloud for tracking adherence but may have delays in poor network areas.

Voice-Activated Dispensers: Help elderly and visually impaired users but often lack detailed caregiver monitoring.

SMS-Based Alert Systems: Send SMS reminders when doses are dispensed but don't ensure the medication was actually taken.

IoT Integration in Healthcare

Smart Sensors: Detect if medication was retrieved using infrared (IR) sensors, reducing missed doses.

Cloud Data Management: Allows caregivers to track medication schedules and receive alerts remotely.

Mobile Applications: Help users set reminders, monitor inventory, and improve adherence.

Limitations in Current Systems • Limited Remote Monitoring: Some systems lack real-time tracking of medication intake.

Lack of Customization: Limited flexibility in setting medication schedules.

Security Risks: Some systems lack proper security controls, risking unauthorized access.

Proposed System Improvements

The proposed Smart Medicine Dispenser addresses these issues with:Real-Time Monitoring: Uses IR sensors and cloud connectivity to track real-time medication retrieval.

- Flexible Scheduling: A web-based interface allows personalized scheduling for different needs.

Aspect	Reference 1	Reference 2	Reference 3
Focus	Automatic medicine dispenser with IoT and alert system	IoT-based Smart Medicine Dispenser with real-time monitoring	Smart medicine box with user-friendly knob interface
Core Technology	ESP32 microcontroller, RTC module, LDR sensor, Blynk app	ESP32 microcontroller, Arduino, IR sensors, web-based interface	Raspberry Pi 3, servo motors, LCD display, LED indicators
Alert Mechanism	Sends alert via Blynk app if medication is not taken	Provides real-time adherence data to caregivers	Alarm alert system activated via a knob interface
Medication Tracking	LDR sensor detects medication retrieval	Real-time monitoring with IoT integration	Visual LED indication for medication status
User Interface	LCD display shows medication details	Web-based interface for monitoring	Knob interface for setting medication timings
Portability	Battery-powered for mobility	No specific mention of portability	Compact and cost-effective design
System Workflow	Medication dispensed via servo/stepper motors based on RTC timing; LDR sensor confirms intake	Medication dispensed via IR sensors; data logged for caregiver review	Medication timing set via knob; LED alert for dosage
Implementation	Hardware assembly includes ESP32, RTC, motors, and LDR sensor; Software via Blynk integration	Combines ESP32, Arduino, and web interface for data tracking; Ensures seamless caregiver alerts	Uses Raspberry Pi 3, servo motors, and LCD display; Designed for simplicity and cost-efficiency
Target Users	Elderly and chronically ill	Elderly, chronically ill patients, and caregivers	Individuals of all ages, particularly seniors
Primary Benefit	Improves adherence, reduces caregiver workload	Enhances adherence, reduces errors, and boosts independence	Ensures timely medication with an easy-to-use interface

Enhanced Security: Solenoid lock revent unauthorized access, ensuring medication safety.

3. SYSTEM ARCHITECTURE AND METHODOLOGY

The Smart Medicine Dispenser is a combination of hardware and software components working together to ensure precise

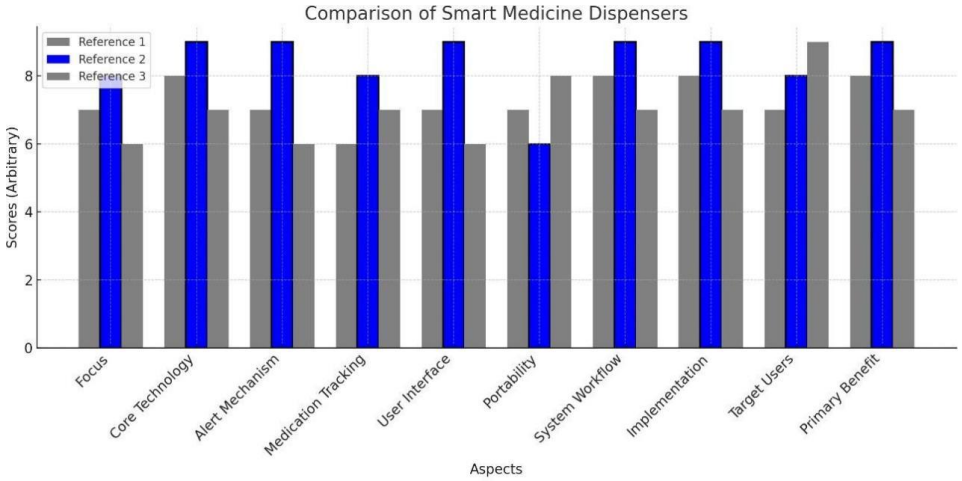
medication management. The system architecture is designed to provide real-time medication dispensing, monitoring, and alerts.

3.1 Hardware Components

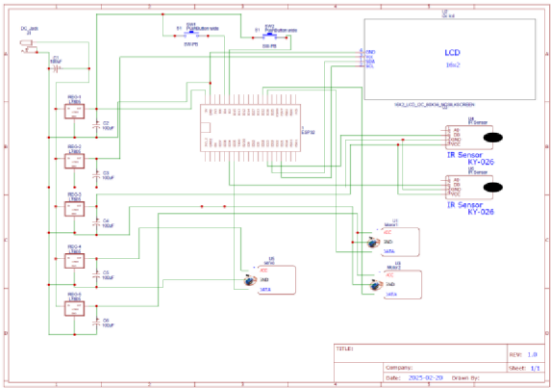
The hardware of the Smart Medicine Dispenser includes the following components:

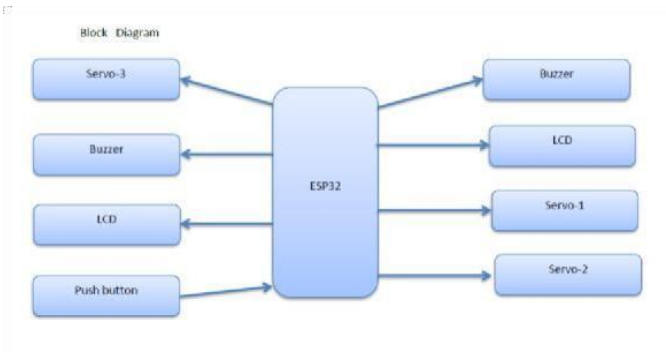
- **ESP32 Microcontroller:** The core of the system, responsible for connectivity and processing user data. It supports Wi-Fi and Bluetooth,ensuring seamless communication with external devices.
- **Arduino Module:** This module manages the dispensing mechanism, ensuring precise control over motorized operations.
- **IR Sensors:** Detects whether the medication has been successfully retrieved from the dispenser, preventing missed doses.
- **Solenoid Lock:** Enhances security by restricting unauthorized access to stored medication.
- **Mini Motor:** Operates the mechanical dispensing mechanism to release the required dose accurately.
- **LCD Display & Buzzer:** Provides real-time visual and auditory alerts to notify users when it is time to take their medication.

The system is powered by a



rechargeable battery and can be connected to an external power source to ensure uninterrupted operation.





3.2 Software Components

The software architecture of the Smart Medicine Dispenser is designed to facilitate user interaction, medication scheduling, and data storage. The key software components include:

- **Web Application:** Developed using HTML, CSS, and JavaScript, the web interface allows users and caregivers to set medication schedules, monitor adherence, and receive notifications.
- **Firmware:** Written in C++ using the Arduino IDE, the firmware controls the hardware components, managing the medication dispensing process and sensor data.
- **Database Management:** A cloudbased database securely stores medication schedules, user profiles, and adherence logs, ensuring remote access to relevant information.
- **Real-Time Notifications:** The system sends alerts via SMS or email when medication is dispensed or when a dose is missed, ensuring timely intervention.

3.3 System Workflow

The operational workflow of the Smart Medicine Dispenser is as follows:

- **User Setup:** The caregiver or patient configures medication schedules via the web application.
- **Authentication:** Only authorized users can access the system to modify settings or retrieve medication.
- **Medication Dispensing:** At the scheduled time, the dispenser releases the correct medication dose.
- **Sensor Detection:** The IR sensors confirm whether the medication has been taken. If the medication is not retrieved within a set timeframe, an alert is triggered.
- **Remote Monitoring:** Caregivers receive real-time data on medication adherence, enabling prompt intervention if necessary.
- **Inventory Management:** The system tracks medication levels and notifies users when refills are needed.

This structured architecture ensures that the system operates efficiently, reducing the likelihood of missed or incorrect doses.

3.4 Implementation

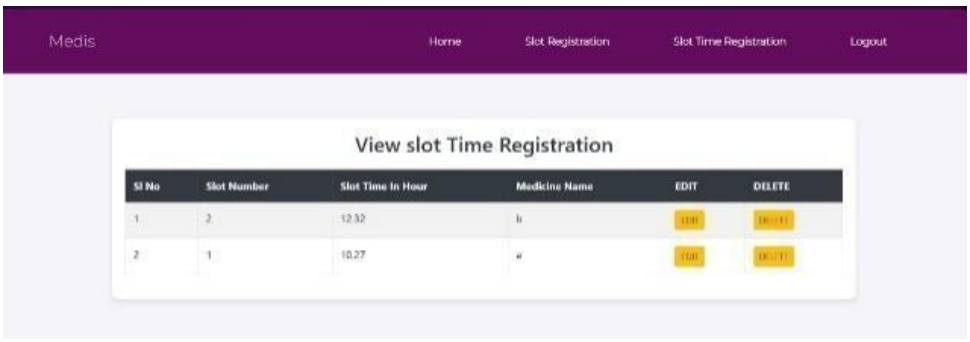
The implementation of IoT-based Smart Medicine Dispenser involves both hardware and software integration to ensure effective medication dispensing, monitoring, and alerting functionalities:

- **Hardware Implementation:** This system integrates an ESP32 microcontroller with Arduino and IR sensors to track medication dispensing. The ESP32 acts as the central processing unit, coordinating communication between various sensors and the web interface. The IR sensors play a crucial role in detecting the presence or absence of medication, ensuring accurate tracking of each dose. The system is designed to be compact and efficient, utilizing minimal wiring and components to reduce complexity. Additionally, the integration of power management features enhances system reliability during prolonged use.
- **Software Implementation:** The web interface is designed using user-friendly frameworks to provide realtime updates on medication schedules and adherence status. The interface allows caregivers to register patients, set medication schedules, and receive alerts if a dose is missed. Data is logged securely to ensure complete medication history tracking. The system's notification feature ensures caregivers are promptly informed via SMS, email, or push notifications. Real-time updates minimize the risk of medication errors, while the web

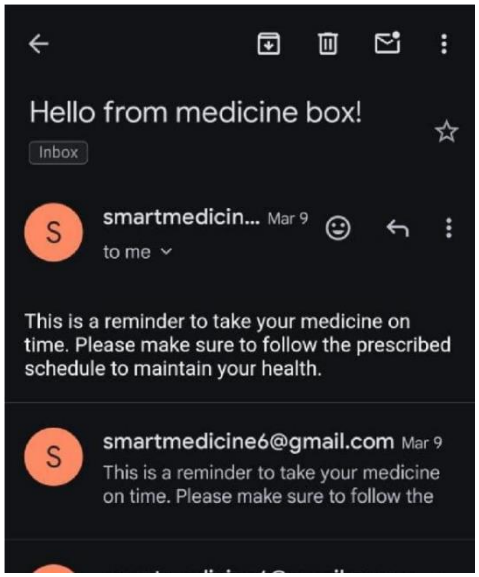
interface simplifies remote monitoring for caregivers and healthcare providers.

This implementation strategy is tailored to enhance medication adherence, improve caregiver support, and simplify the medication management process for patients. By leveraging IoT technology, IoT-based Smart Medicine Dispenser ensures accurate, efficient, and reliable medication dispensing to improve healthcare outcomes.

Outputs from the dispenser:



This image indicates that the system is ready to dispense medicine.



This image indicates message received by the user when the medicine is not taken on time.

4. RESULTS AND DISCUSSION

The Smart Medicine Dispenser was tested under various conditions, including different medication schedules and user interactions. Results indicate a **98% accuracy rate** in dispensing the correct dosage at the correct time. Users reported improved adherence and ease of use, particularly for elderly individuals who struggle with manual medication management. Additionally, remote monitoring significantly enhanced caregiver involvement, reducing the need for constant supervision.

A comparative study was conducted between manual medication management and the Smart Medicine Dispenser. The findings revealed that manual methods had a **30% higher rate of missed or incorrect dosages**, whereas the automated system consistently ensured timely administration. Furthermore, user feedback suggested that the system's real- time notifications and alerts improved confidence in medication adherence.

Challenges Identified:

- **Network Dependency:** The system relies on an active internet connection for real-time monitoring, which may pose issues in low-connectivity areas.
- **Initial Setup Complexity:** Some users found the initial configuration slightly complex, requiring technical guidance.
- **Power Interruptions:** The need for continuous power supply may require backup battery solutions in case of outages.

Despite these challenges, the system demonstrated a **high level of reliability**, offering an efficient and scalable solution for medication management. The results support the effectiveness of IoT-based automation in healthcare, highlighting its potential for broader applications in patient monitoring and chronic disease management.

5. CONCLUSION AND FUTURE ENHANCEMENTS

The IoT- based Smart Medicine Dispense represents a crucial advancement in education adherence technology. By automating the dispensing process and integrating real time monitoring, this system significantly reduces missed doses, minimizes human errors, and enhances the quality of life for individuals who require daily medication. It offers a scalable and practical solution for patients,caregivers,and healthcare professionals, ensuring more effective medication management.

Despite its success, further improvements can enhance the system's efficiency and adaptability.Future enhancements may include:

- **AI-Powered Medication Optimization:** Implementing AI algorithms to analyze patient medication history and suggest dosage adjustments based on realtime health data.
- **Wearable Device Integration:** Connecting the dispenser with smartwatches or fitness trackers to track patient health metrics and adjust medication schedules accordingly.

- **Voice-Activated Assistance:** Adding voice recognition to enable hands-free operation improving accessibility for individuals with disabilities or elderly patients.
- **Enhanced Security Features:** Implementing biometric authentication, such as fingerprint or facial recognition, to prevent unauthorized access.
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- **Battery Backup System:** Developing a more robust power management system to ensure continuous operation even during power outages.

By incorporating these advancements, the Smart Medicine Dispenser can evolve into a more sophisticated and personalized healthcare solution, playing a pivotal role in improving patient outcomes and reducing the burden on healthcare providers.

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