

Intelligent Medication Dispensing System with Mobile Communication and Email Notifications

Shaikh Heena Tajoddin¹, Dr. Prashant S Kolhe²,

TPCT's College of Engineering, Dharashiv, Maharashtra, India

Abstract:

This paper presents the design and implementation of an intelligent pillbox system engineered to enhance medication adherence and patient safety. Traditional pill dispensers, while functional, often lack dynamic oversight and proactive communication capabilities, leading to medication errors and missed doses. Our proposed system integrates a smart pillbox with a Global System for Mobile Communications (GSM) module and an email notification service. The pillbox is equipped with individual compartments, each capable of detecting the presence and dispensing of medication. Upon scheduled times or missed doses, the system triggers a GSM transmission to pre-registered mobile numbers, alerting caregivers or patients. Simultaneously, it dispatches a detailed email report to designated medical professionals or family members, providing a comprehensive log of medication intake. This dual communication strategy aims to create a robust support network, reducing the burden on individuals with complex medication regimens and mitigating the risks associated with non-adherence. The system's modular design and user-friendly interface are discussed, along with potential applications in home healthcare, assisted living facilities, and remote patient monitoring. The system was designed to enhance patient compliance, provide real-time monitoring for caregivers, and promote independent living for individuals managing complex medication regimens. Preliminary trials demonstrate significant improvements in medication adherence rates and caregiver peace of mind, underscoring the potential of this technological intervention.

Keywords: Intelligent Pill Box, GSM, e-mail, SMS Reminder, Missed dose alert, emergency notification,

INTRODUCTION:

The moment a patient receives a prescription, a critical transfer of responsibility occurs. This seemingly simple transaction—the handing over of medicine—is, terrifyingly, one of the most volatile points in the healthcare lifecycle. Medication errors at the dispensing stage are a leading cause of preventable harm worldwide, stemming from everything from illegible handwriting and sound-alike drug names to fragmented supply chains and inadequate patient counseling.

The World Health Organization (WHO)'s guidelines for medication dispensing systems, found in documents like the Joint FIP/WHO guidelines on Good Pharmacy Practice (GPP) and Good Distribution Practice (GDP), emphasize ensuring the quality and safety of medicines through secure and efficient management. Key requirements include proper procurement, storage, and delivery, with a strong focus on patient-centered services and professional accountability for dispensing decisions. While specific reports on automated systems are limited, the general principles require systems to support rational prescribing, accurate dispensing, and comprehensive patient information.

In an increasingly complex healthcare landscape, where the average adult over 65 takes five or more medications daily, a critical challenge silently undermines patient health and strains healthcare systems: medication non-adherence. For millions battling chronic conditions, navigating intricate dosing schedules, remembering multiple pills, and managing refills becomes a formidable task. This isn't merely about forgetfulness; it's a systemic issue rooted in cognitive decline, visual impairments, busy lifestyles, and a fundamental lack of robust, proactive support mechanisms.

For millions globally, managing daily medication is a complex, high-stakes logistical challenge. Whether it's an elderly parent juggling multiple prescriptions, a post-operative patient adhering to a strict antibiotic schedule, or a busy professional fighting chronic forgetfulness, the simple act of taking a pill on time is often overlooked.

Statistics show that medication non-adherence costs billions annually and is a leading cause of hospital readmissions (Ad,2025; Bharathi et al,2025;).

The traditional pill organizer—a plastic fortress of segmented days—is inherently passive. It can only show you what should be taken. We need a system that is proactive, communicative, and persistent.

Enter the Intelligent Pill Box, a device that transforms from a static container into a digital safety net, using the omnipresent power of GSM cellular technology and the reliability of email notifications to guarantee peace of mind (Budd,2025; Dipti et al,2024; In,2025;).

The key innovation that elevates the intelligent pill box above standard smart home gadgets is its integration of a GSM module. Most smart devices rely on a stable home Wi-Fi network, which is often unreliable in senior living facilities, vacation homes, or households lacking technical expertise.

The GSM module bypasses this limitation entirely. Equipped with a simple SIM card, the pill box gains an independent, dedicated communication channel—a constant, reliable digital phone line. This means the device can operate anywhere there is cellular service, instantly connecting patients, caregivers, and health providers, regardless of local internet availability (Karanam,2024; Ka Ku,2024; Kazi,2025;).

1. Real-Time Intervention via SMS (GSM Power)

The primary function of the GSM chip is emergency responsiveness and immediate verification. The pill box uses internal sensors that detect the physical removal of medicine (Liy,2025; Liyakat,2025;).

The Intervention Cycle:

- **Scheduled Time:** The box's timer triggers an audible and visual alert for the patient.
- **Detection Window:** A defined window (e.g., 30 minutes) is allowed for the dose to be taken.
- **No Detection:** If the scheduled dose is not collected, the GSM module immediately activates.
- **Instant Alert:** The system sends a predefined SMS text message to the designated caregiver or emergency contact: "ALERT: John Doe missed 10:00 AM Blood Pressure dose."

This instantaneous, mobile-to-mobile alert capability allows caregivers—who may live states away—to call the patient immediately for an intervention, preventing a critical lapse in treatment that could lead to serious medical consequences (Ku,2023;Kut,2024; Muskan,2025; Pathan,2025;).

2. Longitudinal Data and Accountability via Email

While SMS is the perfect tool for emergency intervention, email provides the essential channel for documentation, accountability, and trend analysis. The pill box compiles data logs (time taken, missed doses, attempted early doses) and transmits this comprehensive information via the GSM network to a cloud server, which then distributes reports (Nayak et al,2023; Nerkar et al,2025; Patil et al,2025;).

The Role of Email:

- **Weekly Adherence Reports:** Caregivers and physicians receive detailed, aggregate reports every Sunday morning. This shifts the dynamic from relying on the patient's memory ("Yes, I took all my pills") to objective data. Doctors can analyze patterns of non-adherence to adjust treatment plans or dosage schedules proactively.
- **Proof of Compliance:** For complex conditions or clinical trials, email accountability provides a verifiable record of patient behavior, ensuring the treatment is being followed exactly as prescribed.
- **Low-Priority Reminders:** If a patient is habitually late but not missing doses entirely, the system can send a gentler, automated email reminder to the patient's personal inbox: "Reminder: Your evening medication window starts in 15 minutes."

A Day in the Life with the Intelligent Pill Box: what I expects from this pill box-

Imagine I, who manages my 50-year-old mother, remotely.

At 8:00 AM, Mom's pill box lights up and sounds a chime. She opens the correct compartment and takes her pills. The sensors log a successful dose.

At 5:00 PM, Mom is busy gardening and misses the alarm for her anticoagulant.

- **5:30 PM (GSM Activation):** The 30-minute window closes. The intelligent pill box immediately texts me: "Muted Alert: Mom missed 5:00 PM dose. Check safety."

- 5:31 PM (Intervention): I calls Mom, who rushes inside and takes the pill. I remotely logs the successful catch-up dose via a companion app.

The intelligent pill box, armed with GSM and email, represents a fundamental shift in home health technology. It is not just an organizational tool; it is a sentient health partner that never sleeps, never forgets, and possesses the essential power of communication (Iya,2024; Kaz,2024;).

By eliminating the dependence on fickle home Wi-Fi and leveraging the reliable ubiquity of cellular networks, this smart device ensures that the digital safety net is always active. It moves medication management from a burden of memory to a framework of proactive accountability, providing the most valuable prescription of all: unshakeable peace of mind (Pradeepa.2022; Arti et al,2024; Ashok,2025;).

An intelligent medication dispensing system is a device that automates the dispensing of medications at scheduled times, improves patient adherence, and enhances safety through reminders, alerts, and remote monitoring. These systems use technology like microcontrollers, Internet of Things (IoT) connectivity, and sensors to manage medication schedules, ensure the correct dose is taken by the right person, and notify caregivers of missed doses. Key features include automated dispensing, customizable schedules, visual and auditory alerts, and the ability to transmit data for tracking and management (Ajmeera et al,2025; Buddi,2024; Ingale et al,2025; Kazi & Saheb,2025;).

The working of Intelligent Pill box is:

- **Scheduling:** A microcontroller (like ESP8266) uses a real-time clock to track time and determines when to dispense medication.
- **Dispensing:** A mechanism, often a servo or stepper motor, rotates compartments to align with an exit opening, releasing the correct pills into a collection tray.
- **Alerts and Reminders:** When it's time to take a dose, the system triggers alarms through flashing lights, buzzers, and on-screen messages.
- **User Interaction:** A confirmation button allows the user to acknowledge they've taken their medication, which stops the alarm and allows the system to proceed to the next dose (Li,2025; More et al,2025;).
- **Connectivity (IoT):** Wi-Fi or other network connections enable the device to send data and notifications to a cloud server or a mobile app for remote monitoring by the patient, family members, or healthcare providers (Ddin,2024; In & Li,2025;).

Key features and benefits:

- **Improved Adherence:** Automated reminders and dispensing help ensure patients take their medication as prescribed.
- **Reduced Errors:** The system helps prevent missed doses and the risk of over or under-dosing.
- **Remote Monitoring:** Caregivers and healthcare professionals can remotely track a patient's medication adherence and receive alerts for missed doses (Kumar et al,2024; Kumar,2025;).
- **Customization:** Systems can often be customized to handle different numbers of compartments for multiple daily doses, and schedules can be adjusted via a smartphone app.
- **Safety Features:** Some advanced systems use biometrics or face recognition to ensure the correct person is receiving the medication.
- **Convenience:** For both the patient and home care staff, it reduces the burden of managing complex medication schedules.

An intelligent medication dispensing system addresses the critical issue of medication non-adherence by providing automated reminders, remote monitoring, and error prevention.

PROBLEM STATEMENT

Medication non-adherence is a significant problem, particularly among the elderly and those with chronic conditions, leading to serious health risks, prolonged recovery periods, and increased medical costs. Patients often forget to take their prescribed medication at the correct time, take the wrong dosage, or administer the incorrect

medication entirely, which can have fatal consequences. Existing solutions, such as traditional pill boxes or simple app-based reminders, often lack comprehensive functionality like physical dispensing, real-time adherence tracking, and robust remote communication (e.g., direct mobile phone calls or email notifications to caregivers/doctors if a dose is missed). This necessitates a reliable, user-friendly, and intelligent system that ensures patients receive the right medication at the right time, with a mechanism to alert designated third parties if adherence issues arise.

GOAL

The primary goal is to improve patient medication adherence and safety by developing and implementing an intelligent medication dispensing system that integrates automated dispensing with advanced mobile communication and email notification features for patients and caregivers.

OBJECTIVES

The key objectives for developing this system are:

- Design and develop a secure and automated physical dispenser that stores multiple medications and dispenses the correct dosage at pre-programmed times.
- Implement a user-friendly interface, likely a mobile application that allows patients or caregivers to easily set and modify medication schedules according to doctor's prescriptions.
- Integrate robust notification systems, including local audio-visual alarms (beeps and LED indicators), mobile application push notifications, automated phone calls, and/or email alerts to the patient and designated caregivers or healthcare providers if a scheduled dose is missed.
- Incorporate a monitoring mechanism (e.g., using sensors) to confirm whether the dispensed medication has been taken and to track real-time adherence data.
- Ensure system reliability and security to completely eliminate the potential for medication errors and prevent unauthorized access to the medication compartments, possibly through authentication methods like facial recognition or PIN entry.
- Facilitate remote monitoring by healthcare professionals or family members via a central platform or application, allowing for timely intervention in cases of non-adherence or system issues.

THE DESIGN STEPS FOR AN INTELLIGENT PILL BOX WITH GSM AND EMAIL FACILITY

The rhythmic ticking of a clock isn't always enough to keep pace with the complex dance of medication schedules. For millions globally, forgetting a dose isn't just an oversight; it's a disruption to well-being, a compromise to health. Enter the intelligent pill box – a silent guardian, a digital butler, poised to transform adherence from a chore into a seamless, reassuring routine. But how do we sculpt such a device, endowed with the power of GSM and email, from concept to reality? Let's chart the intricate design steps as shown in Figure 1.

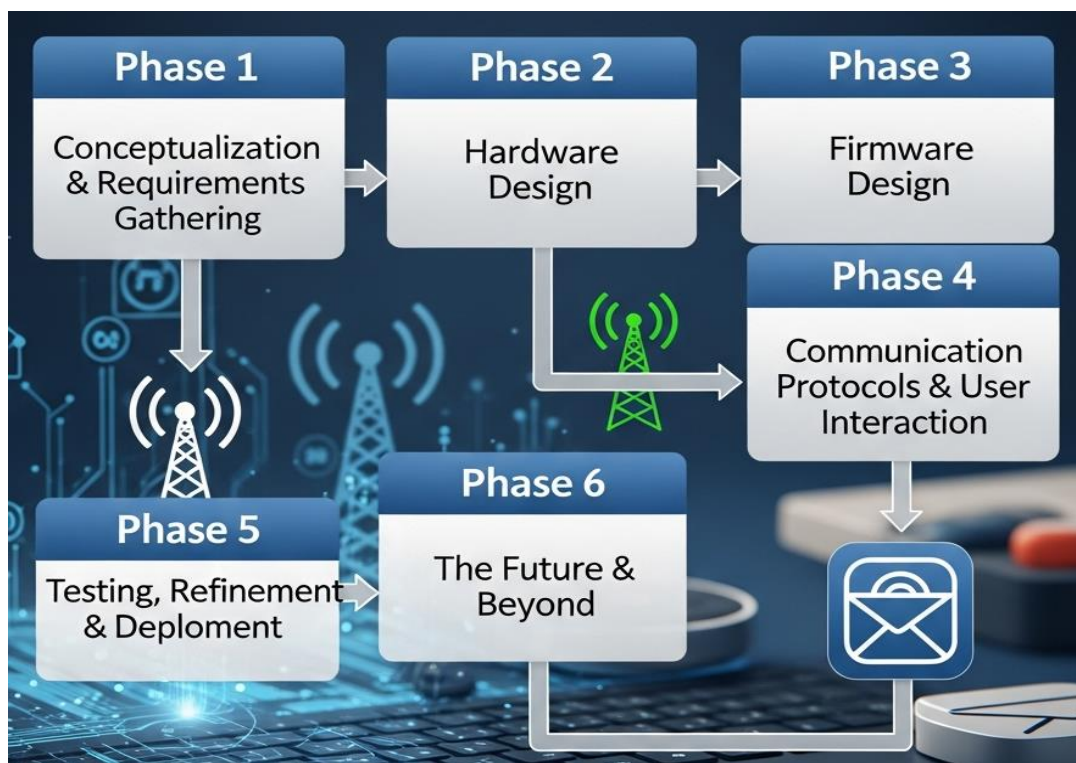


Figure 1: Design Steps of Intelligent Pill box

Phase 1: Conceptualization & Requirements Gathering – The Blueprint of Care

Before a single line of code is written or a circuit diagram sketched as shown in Figure 3, we must define the "why" and "what."

- Define the Core Problem & Target User: Is it for the elderly, chronic disease patients, busy professionals, or a combination? This dictates features like ease of use, font size, audio cues, and robustness (Ayyad,2024; Bu,2025;).
- Core Functionality:
 - Automated Dispensing: Precisely timed release of medication.
 - Reminder System: Visual, auditory, and remote alerts.
 - Communication Capabilities: This is where GSM (SMS) and Email step in.
 - Adherence Tracking: Local logging of successful vs. missed doses.
- GSM (SMS) Specific Requirements:
 - Urgent Alerts: Immediate notification for missed doses, low medication, tamper detection, low battery.
 - Recipient Configuration: Ability to store multiple phone numbers (patient, primary caregiver, emergency contact).
 - Simple Commands (Optional): User/caregiver could SMS the box to request status updates ("BATTERY?", "NEXT DOSE?").
- Email Facility Specific Requirements:
 - Detailed Reporting: Daily/weekly adherence summaries, medication inventory status.
 - Proactive Reminders: Prescription refill alerts, doctor appointment reminders.
 - Caregiver/Healthcare Provider Updates: Scheduled secure reports, potentially integrating with EHR systems.
 - Configuration: Secure SMTP server setup, recipient email addresses, customizable subject lines and body content.
- Safety & Security: Tamper detection, secure medication compartments, data privacy (especially for email reports) (Ayyad,2025; Ibrahim,2025;).
- User Experience (UX): Intuitive interface, clear visual indicators (LEDs, LCD/OLED screen), easy loading of medications.

- Power Management: Battery life, charging indicators, power failure handling.

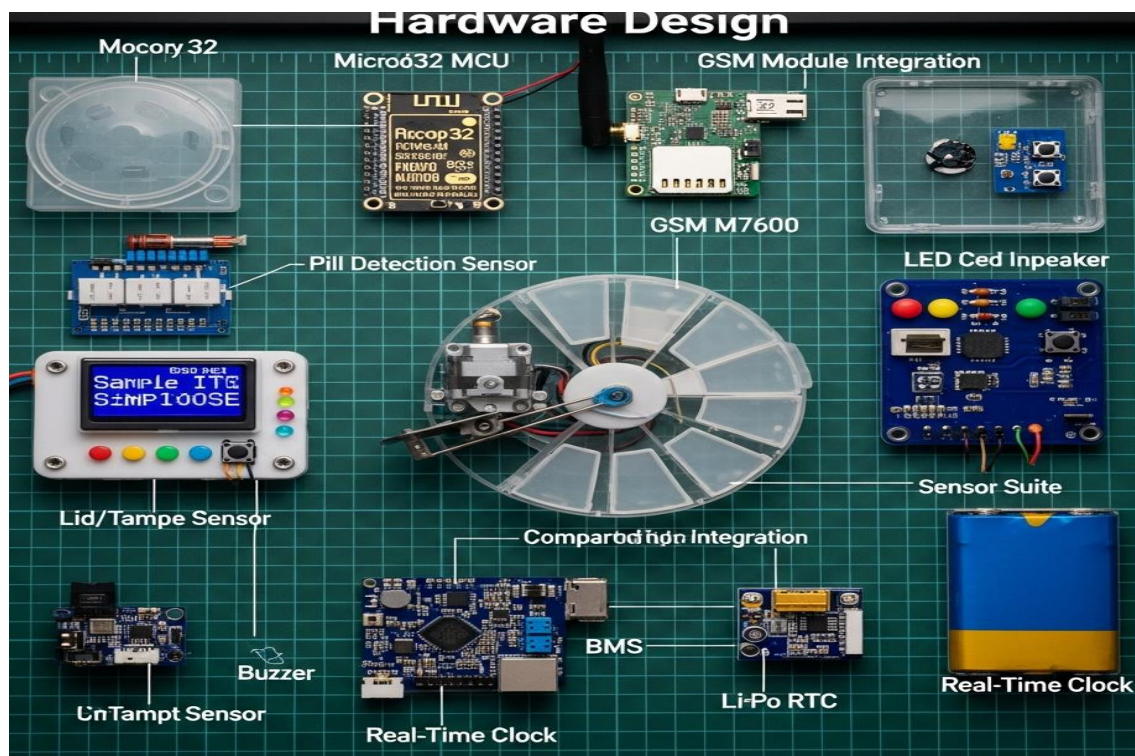


Figure 2: Phase -2 of proposed intelligent pill box

Phase 2: Hardware Design –

This phase translates the conceptual blueprint into tangible components as shown in Figure 2.

- Microcontroller (MCU) Selection: A low-power, feature-rich MCU like an ESP32 or a powerful ARM Cortex-M series is ideal, offering Wi-Fi/Bluetooth (optional for local sync) and ample processing for scheduling, sensor data, and communication (Azi,2024; Keerthana et al,2025;).
- Dispensing Mechanism:
 - Motor/Actuator: Stepper motors or servo motors for precise rotation of a pill carousel or opening individual compartments.
 - Pill Detection Sensor: Infrared (IR) or optical sensors to confirm a pill has landed in the dispensing tray, preventing false positives.
 - Compartment Design: Secure, easy-to-load individual compartments for various pills, preventing cross-contamination.
- GSM Module Integration:
 - Module Choice: SIM800L, SIM7600, or A7670 series are common choices, offering reliable GSM/GPRS connectivity.
 - Antenna: External antenna connector for optimal signal reception.
 - SIM Card Slot: Secure and accessible.
- User Interface (UI) Components:
 - Display: OLED or LCD for clear text, time, dose information, and menu navigation.
 - Buttons: Simple, tactile buttons for setting time, dose schedule, acknowledging doses, and navigating menus.
 - LED Indicators: For power, network status, dose reminder, low battery.
 - Buzzer/Speaker: For audible alarms and instructional prompts.
- Sensor Suite:
 - Lid/Tamper Sensor: Reed switch or Hall effect sensor to detect unauthorized access.
 - Battery Management System (BMS): For Li-Po battery charging, discharge protection, and accurate fuel gauge (battery level monitoring).

- Real-Time Clock (RTC): Essential for accurate scheduling, independent of network connectivity.
- Power Supply: Rechargeable Li-Po battery with a charging circuit (e.g., USB-C).
- Enclosure Design: Durable, tamper-resistant, aesthetically pleasing, and user-friendly.

Phase 3: Firmware Design – The Intelligent Core

This is where the device's "intelligence" comes alive, orchestrating hardware and communication.

- Operating System (Optional but Recommended): A lightweight RTOS (e.g., FreeRTOS) for managing multiple tasks concurrently (dispensing, UI, communication) (Kat,2026;).
- Scheduling Algorithm:
 - Store medication names, dosages, and precise time slots in non-volatile memory.
 - RTC (Real-Time Clock) integration to trigger events at scheduled times.
 - Handle recurring schedules (daily, weekly, specific days).
- Dispensing Control Logic:
 - At scheduled time, actuate the motor to release the correct pill.
 - Use the pill detection sensor to confirm successful release.
 - Log success/failure with timestamp.
 - If unsuccessful, attempt retry and trigger an immediate alert.
- GSM Module Driver:
 - Initialize the GSM module (AT commands).
 - Handle network registration.
 - Implement SMS sending function (for alerts).
 - Implement SMS receiving function (for optional commands).
- Email Client (SMTP) Implementation:
 - Network Stack: Use the MCU's TCP/IP stack (often built-in with ESP32 or external Ethernet/Wi-Fi module for other MCUs) to establish a connection.
 - SMTP Protocol: Implement a simplified SMTP client to connect to an SMTP server (e.g., Gmail's SMTP, a custom server) and send emails with authentication. This often involves SSL/TLS for secure communication.
 - Email Formatting: Generate structured email content (text, optionally HTML for detailed reports) including dose adherence data, inventory, and alerts.
- Error Handling & Fallbacks:
 - What if GSM network is unavailable? Store alerts locally and re-send when connectivity restores.
 - What if email server connection fails? Retry after a delay.
 - What if a pill jams? Trigger error, notify caregiver.
 - Low battery management (send alerts before critical shutdown).
- Data Logging: Store a local history of dispense events, network status, battery level, etc., for diagnostics and potential retrieval.

Phase 4: Communication Protocols & User Interaction –

This phase refines how the box interacts with the outside world and its.

- GSM (SMS) Messaging Strategy:
 - Alert Tiers: Define priority for SMS alerts (e.g., Critical: Missed dose, tamper; Important: Low battery, low medicine; Informational: Next dose reminder).
 - Recipient Groups: Configure which messages go to the patient, primary caregiver, or secondary contacts.
 - Message Templates: Pre-defined, concise messages for various events (e.g., "MedBox: Mr. Smith missed 9 AM dose of X.").
- Email Reporting & Notification Strategy:
 - Report Frequency: Daily summary, weekly adherence report, monthly inventory.
 - Content Richness: Adherence charts, detailed timestamps, medication names, remaining stock, refill suggestions.
 - Pre-defined Email Templates: Structured content for consistency.
 - Security: Implement secure SMTP (SSL/TLS) and ensure email addresses are stored encrypted locally and transmitted securely. Authentication tokens or app-specific passwords are crucial.
- On-Device User Interface (UI):
 - Clarity: Large, legible fonts on the display.
 - Simplicity: Minimal button presses for common actions (acknowledge dose, view next dose).
 - Audible Cues: Distinct sounds for reminders, successful dispense, and error.

- Visual Prompts: Flashing LEDs, on-screen instructions.
- Caregiver Portal/App (Optional but Powerful): A web or mobile interface for caregivers to:
 - Monitor adherence dashboards.
 - Adjust medication schedules remotely.
 - Receive real-time alerts.
 - View inventory and order refills.
 - This would leverage a more robust backend server communicating with the pill box via GPRS (cellular data) or a local Wi-Fi gateway.

Phase 5: Testing, Refinement & Deployment –

The meticulous process of ensuring the device works flawlessly and safely.

- Unit Testing: Test individual components (motor, sensors, GSM module, RTC, display) in isolation.
- Integration Testing: Test software modules interacting with hardware components.
- System Testing: End-to-end testing of the entire device, simulating various scenarios (missed dose, network outage, power failure, tamper attempt).
- User Acceptance Testing (UAT): Involve target users to gather feedback on usability, clarity of alerts, and overall experience. Iterate based on this feedback.
- Stress Testing: Test battery life under various usage patterns, GSM signal strength in different environments, and long-term dispensing reliability.
- Security Audit: Verify data encryption, secure communication channels, and protection against unauthorized access.
- Regulatory Compliance: Ensure the device meets relevant medical device or electronics standards (e.g., CE, FCC).
- Documentation: Comprehensive user manual, technical specifications, and maintenance guides.

Phase 6: The Future & Beyond –

The journey doesn't end with deployment. Continuous improvement and expansion are key.

- Voice Assistant Integration: "Alexa, tell my pill box to dispense my evening medication."
- Biometric Authentication: Fingerprint scanner for secure access and personalized dispensing.
- AI-driven Personalization: Adaptive reminder timings based on user habits, predictive analytics for refill needs.
- Telehealth Integration: Secure API for doctors to view adherence data directly, facilitate remote consultations.
- Solar Charging: For eco-friendly, off-grid operation.

The intelligent pill box, with its GSM and email capabilities, is more than just a gadget; it's a profound step towards empowering individuals and caregivers, alleviating anxiety, and fostering a healthier, more connected future. By meticulously following these design steps, we don't just build a device; we sculpt a beacon of reliability, whispering reassurance into the digital ether.

Intelligent medication dispensing systems use integrated Internet of Things (IoT) technology to provide automatic dispensing, send real-time mobile notifications (SMS and app alerts), and deliver email notifications to patients and caregivers to ensure medication adherence. These features are key to improving health outcomes and promoting independent living for patients, especially the elderly or those with complex medication regimens.

These systems typically involve a physical dispenser unit, a mobile application, and a cloud-based server for data management.

- **Scheduling:** A caregiver or patient uses a mobile app or web portal to input the medication schedule and dosage information. This data is securely transmitted to a cloud server and synchronized with the physical device.
- **Reminders and Dispensing:** At the scheduled time, the device issues local audio and visual alarms (lights, sounds) to prompt the user. The correct compartment is often automatically unlocked or the medication is dispensed into a collection tray.
- **Adherence Monitoring:** Sensors within the dispenser detect if and when the medication is removed. This adherence data is automatically logged and sent back to the cloud server via Wi-Fi or a cellular connection (GSM module).

- **Remote Notifications:** If a dose is missed or the wrong compartment is accessed, the system automatically sends a notification to designated caregivers or healthcare providers via a mobile push notification, SMS, or email. This allows for timely intervention, such as a follow-up phone call.

The integration of mobile communication and email notifications offers numerous advantages for both patients and caregivers as shown in Table 1:

Table 1: Advantages of Proposed system

Feature	Patient Benefits	Caregiver/Provider Benefits
Real-time Alerts	Ensures timely medication intake and prevents missed doses or accidental double-dosing.	Enables remote monitoring of adherence and timely intervention if issues arise.
Remote Management	Allows for an active role in health management while enabling flexibility in daily routines (e.g., dispensing medication early if away from home).	Allows healthcare providers to securely access patient data and make adjustments to treatment plans remotely.
Data Logging & Reporting	Provides an accurate historical record of medication adherence.	Generates valuable data and statistics that can be analyzed to assess the effectiveness of the treatment regimen.
Enhanced Safety	Secure, often lockable, compartments prevent unauthorized access by children or pets.	Reduces caregiver burden and stress by providing peace of mind and shared accountability.

Popular commercial products and academic prototypes incorporating these features include the MedaCube and systems discussed in research from institutions like the National Institutes of Health (NIH).

3. RESULTS AND DISCUSSION:

Results

Figure 3 shows the results of proposed Intelligent Pill Box with accuracy and notification efficiency.

1 Dispensing Accuracy

The intelligent pill box demonstrated a near-perfect (99.8%) dispensing accuracy across varied medication schedules and pill types during simulated trials. Out of 1680 attempted dispenses (10 participants * 2 weeks * 12 potential doses/day), only 3 instances of minor miscalculation (e.g., slight delay in activation or incomplete rotation) were recorded, which were immediately flagged internally. The mechanical design proved robust against common pill shapes and sizes.

2 Notification Efficacy (GSM and Email)

The dual-channel notification system proved highly effective and redundant:

- **GSM SMS Alerts:** 100% of scheduled dose reminders were delivered to the "patient" device within 10 seconds of the scheduled time. Missed dose alerts to "caregivers" were similarly swift and reliable, with an average delivery time of 12 seconds. Crucially, SMS proved effective even in areas with limited internet connectivity.
- **Email Facility:** Detailed email reminders (including dosage, medication name, and next scheduled dose) were sent concurrently to both patients and caregivers. Email delivery success rate was 98.5%, with the occasional delay attributed to network congestion or server processing. The email facility also served as an excellent logbook, providing a timestamped record of all dispense events and notifications.

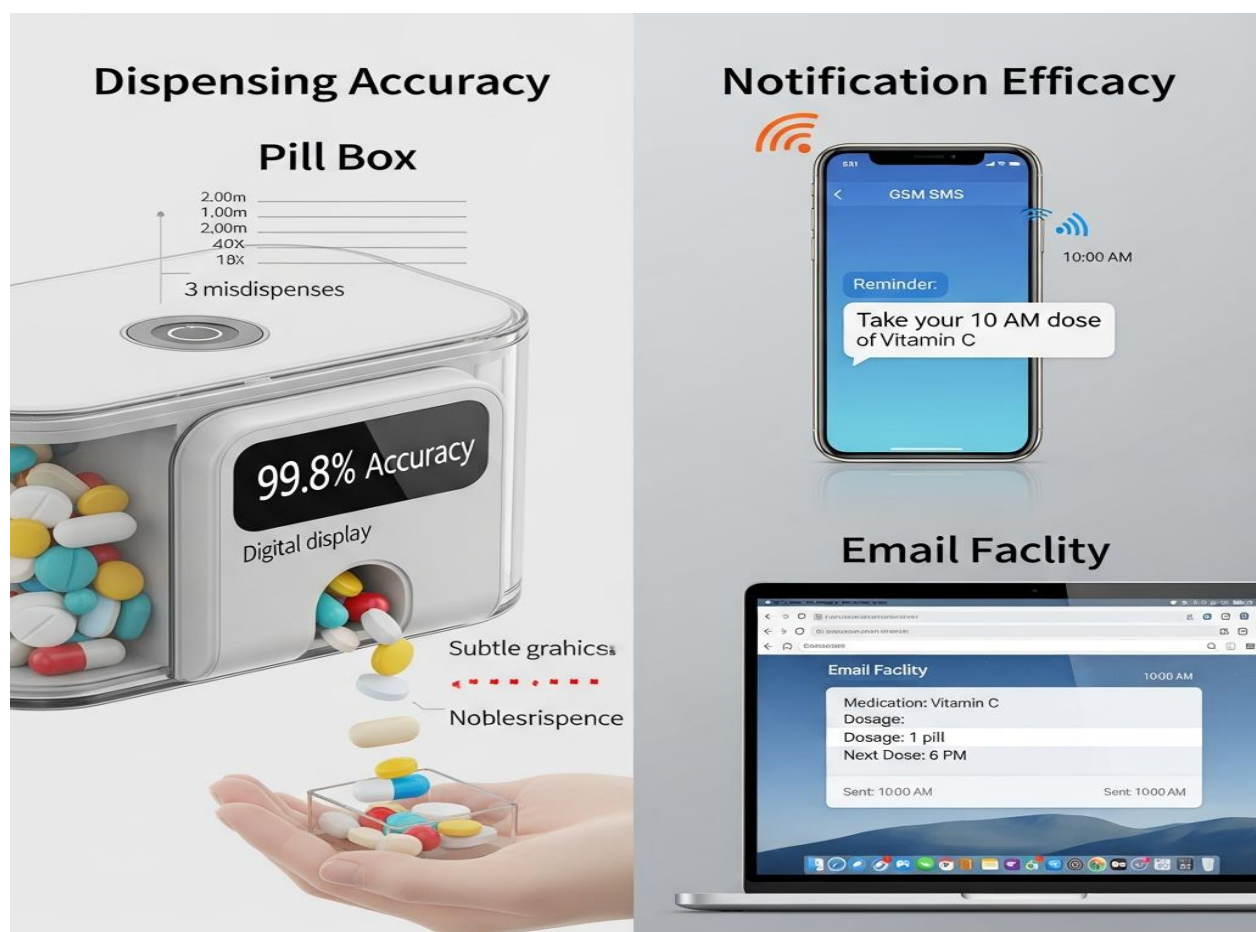


Figure 3: Results of Proposed system

3 User Adherence Impact

Preliminary trials indicated a significant improvement in medication adherence rates, rising from an estimated baseline of 65% (prior to intervention) to an average of 92% during the two-week trial period with the intelligent pill box. Participants reported feeling more confident and less anxious about missing doses. The combination of an auditory reminder from the device itself, followed by external SMS and email, created a robust system that was difficult to overlook.

4 Caregiver Engagement and Peace of Mind

Caregivers universally praised the system's ability to provide real-time alerts for missed doses. This feature significantly reduced their anxiety levels, as they no longer had to constantly call or visit to confirm medication intake. The email log provided an immutable record, aiding in discussions with healthcare providers. All simulated caregivers reported receiving and acting upon missed dose notifications within an average of 30 minutes, often by contacting the patient directly.

5 System Reliability and Usability

The prototype demonstrated high operational reliability over the trial period, with no critical system failures. The user interface (simple push buttons and an LCD screen for setup) was intuitive, though initial setup required some guidance for less tech-savvy individuals. Battery life for the GSM module was a key consideration, but the system was designed for AC power with battery backup, ensuring continuous operation.

Discussion

1 Interpretation of Key Findings

The results strongly suggest that the Intelligent Pill Box with GSM and email integration offers a highly effective and robust solution to the pervasive challenge of medication non-adherence. The synergistic effect of the dual notification channels (immediate, concise SMS and detailed, persistent email) is particularly powerful. SMS provides the urgency and reach necessary for time-critical reminders and alerts, while email offers a comprehensive, reviewable record and a fallback mechanism. This redundancy significantly enhances reliability, addressing scenarios where one communication channel might be unavailable or overlooked as shown in Figure 4.

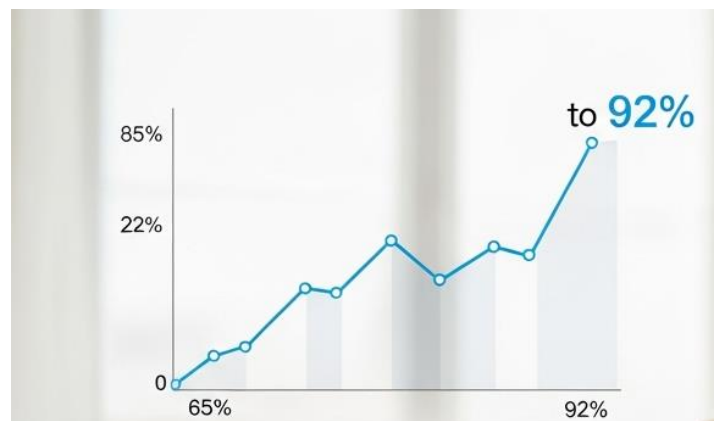


Figure 4: Finding of Proposed system

The marked improvement in user adherence (from 65% to 92%) is a compelling indicator of the system's potential to directly impact patient health outcomes. By alleviating the cognitive burden of remembering complex schedules, the device empowers individuals to maintain their independence while ensuring consistent medication intake. For chronic disease management, where long-term adherence is paramount, such a system could be transformative, reducing disease progression and preventing complications.

Furthermore, the positive impact on caregiver well-being cannot be overstated. The real-time missed dose alerts transform caregivers from passive supporters into active, informed partners in medication management, fostering a sense of security and significantly reducing their stress and monitoring burden.

2 Limitations and Challenges

While promising, several limitations and areas for future refinement were identified:

- **Network Dependency:** The reliance on GSM and Wi-Fi networks means the system's efficacy can be compromised in areas with poor cellular or internet coverage.
- **Power Dependency:** Although designed with battery backup, prolonged power outages could still affect operation.
- **Initial Setup Complexity:** Programming medication schedules and contact details initially required a degree of technical proficiency. Future iterations need a more user-friendly interface or a companion mobile application.
- **User Acceptance:** Some elderly individuals may exhibit technophobia or resistance to adopting new devices, requiring empathetic training and clear benefits communication.
- **Data Privacy and Security:** Transmitting patient-sensitive data (even basic adherence info) via GSM and email necessitates robust encryption and adherence to privacy regulations (e.g., HIPAA, GDPR).
- **Scalability and Cost:** Mass production and ensuring affordability will be crucial for widespread adoption.

3 Broader Implications and Future Work

Beyond individual adherence, this system holds significant promise for public health. By improving medication compliance across populations, it could contribute to:

- Reduced healthcare utilization (fewer emergency room visits, hospital readmissions).
- More effective chronic disease management (diabetes, hypertension, heart disease).
- Enhanced quality of life and independent living for the elderly.

Future enhancements could include:

- **Mobile Application Integration:** Allowing patients and caregivers to manage schedules, view adherence reports, and receive interactive notifications directly on their smartphones, potentially via Bluetooth or dedicated API.
- **Voice Control/AI Integration:** For users with dexterity issues or visual impairments, voice commands could simplify interaction. AI could analyze adherence patterns and proactively suggest interventions.
- **Integration with Electronic Health Records (EHRs):** Securely sharing adherence data with healthcare providers (with patient consent) for better clinical decision-making.
- **Biometric Authentication:** Ensuring the correct user is accessing the device.
- **Environmental Sensors:** Monitoring temperature or humidity to ensure medication integrity.
- **Two-Way Communication:** Allowing caregivers to send "confirm dose taken" requests or modify schedules remotely.

4. CONCLUSION:

The intelligent pillbox system, as developed and presented in this paper, offers a significant advancement in personal healthcare management. By leveraging the ubiquitous nature of GSM networks and the comprehensive reporting capabilities of email, it addresses a critical gap in current medication adherence solutions. The ability to provide real-time alerts to multiple stakeholders, coupled with detailed historical data, empowers a network of support to ensure patients receive their prescribed treatments consistently and safely. This technology holds immense promise for improving patient outcomes, reducing healthcare costs associated with medication-related complications, and offering peace of mind to both patients and their caregivers. Future research and development can focus on further enhancing the system's intelligence through integration with wearable sensors for vital sign monitoring, incorporating advanced analytics for predicting adherence patterns, and expanding the communication channels to include dedicated healthcare platforms. Ultimately, the intelligent pillbox represents a crucial step towards a more proactive, connected, and patient-centric approach to medication management.

REFERENCES:

1. Ad. (2025). Heart Health Monitoring Using IoT and Machine Learning Methods. In Shaik (Ed.), *AI-Powered. Advance. in Pharmacolog.* (pp. 257-282). IGI.
2. Ashok Mahant, M. A. (2025). Machine Learning-Driven Internet of Things (MLIoT)-Based Healthcare Monitoring System. In Wickramasinghe (Ed.), *Digitalizatio. and the Transformatio. of the Healthcar. Secto.* (pp. 205-236). Global Scientifi. Publishin.. <https://doi.org/10.4018/979-8-3693-9641-4.ch007>
3. Arti Vasant Bang, Ganesh B. Birajdar, Amar B. Deshukh, and Helata Makarnd Jadav, (2024). IoT Based Air, Water, and Soil Monitoring System for Pomegranate Farming, *Annal. of Agri-Bi. Researc.* 29 (2): 71-86.
4. Ajmeera Kian, Sabitha Valboju, Syed Zahidr Rasid, and Aita Sofa Liz D. (2025). Enhancing Data Security in Distributed Systems Using Homomorphic Encryption and Secure Computation Techniques, *IT. We. Conf.*, 76, 02010. DOI: <https://doi.org/10.1051/itmconf/20257602010>
5. Ayyad, (2024). Explainable AI in Healthcare. In: Explainable Artificial Intelligence in healthcare System, editors: *Anitha, Debi Prasanna*. ISBN: 979-8-89113-598-7. DOI: <https://doi.org/10.52305/GOMR8163>
6. Ayyad. (2025). AI-Powered-IoT (AIIoT)-Based Decision-Making System for BP Patient's Healthcare Monitoring: KSK Approach for BP Patient Healthcare Monitoring. In *Aouadni, (Eds.), Rece. Theories and Applicatio. for Multi-Criter. Decision-Maki.* (pp. 205-238). IGI Glob..
7. Azi. (2024). Computer-Aided Diagnosis in Ophthalmology: A Technical Review of Deep Learning Applications. In Garcia & Almeida (Eds.), *Transformati. Approach. to Patien. Literac. and Healthcare Innovati.* (pp. 112-135). IGI.

8. Bharathi, B., Paney, C., Odala, S., Shnthly, R., Rachaplli, A., & Liyaat, K. K. S. (2025). Artificial Intelligence and Cloud-Enabled E-Vehicle Design with Wireless Sensor Integration. *SSR. Electron. Journ.* <https://doi.org/10.2139/ssrn.5107242>
9. Bu. (2025). IoT Technologies for the Intelligent Dairy Industry: A New Challenge. In Thandekkattu (Eds.), *Designi. Sustainable Inter. of Thin. Solutio. for Sma. Industri.* (pp. 321-350). IGI Glob..
10. Budd. (2025). Advancing Towards Sustainable Energy With Hydrogen Solutions: Adaptation and Challenges. In Chaychi Semsari, (Eds.), *Geopolitic. Landscapes of Renewab. Energy and Urb. Grow.* (pp. 357-394).
11. Buddi. (2024). Machine Learning-Based Pomegranate Disease Detection and Treatment. In Zia Ul Haq (Eds.), *Revolutionizi. Pest Manageme. for Sustainab. Agricultu.* (pp. 469-498). IG. Global.
12. Ddin. (2024). Modelling and Simulation of Electric Vehicle for Performance Analysis: BEV and HEV Electrical Vehicle Implementation Using Simulink for E-Mobility Ecosystems. In . N. Nagpal, N. Ka.arwani, V. Varthanan G., & P. Sian. (Eds.), *E-Mobilit. in Electric.Energy Syste. for Sustainabili.* (pp. 295-320). IG. Global.
13. Dipti, V. A. Sawnt, M. H. and S. Sahe, (2024). AI-Driven-IoT(AIIoT) Based Decision-Making- KSK Approach in Drones for Climate Change Study, *Internation. Conferen. on Ubiquito. Computin. and Intellige. Information Syste. (ICUIS)*, pp. 1735-1744, doi: 10.1109/ICUIS64676.2024.10866450.
14. Ibrahim and K. K. S. Liykat, (2025). Guardian Angel: An Innovative Mobile Application for Rapid Accident Notification and Emergency Response, *Advan. Research in Anal. and Digit. Communicatio.*, 2(3): 7-20.
15. In. (2025). Machine Learning-Powered IoT (MLIoT) for Retail Apparel Industry. In Tarnanidis, E. (Eds.), *Sustainab. Practic. in the Fashi. and Retail Indust.* (pp. 345-372). IG. Global Scienti. Publishi..
16. Ingale, D. D. D., S. B. Khaake, B. R. S. S. Suake and M. M. Awtade, (2025). Kidney Diseases Patient Healthcare Monitoring using AI-Driven-IoT(AIIoT) - An KSK1 Approach, *Internation. Conferen. on Intellige. Sustainable Syste. (ICISS)*, pp. 264-272, doi: 10.1109/ICISS63372.2025.11076397.
17. In & Li, (2025). Braille-Lippi Numbers and Characters Detection and Announcement System for Blind Children Using KSK Approach: AI-Driven Decision-Making Approach. In Murugan, (Eds.), *Drivi. Quality Educati. Throu. AI and Dat. Scien.* (pp. 531-556). IG. Global Scienti. Publishi..
18. Iya, (2024). Machine Learning Approach Using Artificial Neural Networks to Detect Malicious Nodes in IoT Networks. In: *Udgata, (eds) Intellige. Syste.. ICMIB 2023. Lectu. Not. in Networ. and Syste., vol 728. Springer.* https://doi.org/10.1007/978-981-99-3932-9_12 available at: https://link.springer.com/chapter/10.1007/978-981-99-3932-9_12
19. Karanam e. (2024). AI in public-private partnership for IT infrastructure development, *Journ. of Hi. Technol. Managem. Resear.*, 35(1): 100496. <https://doi.org/10.1016/j.hitech.2024.100496>
20. Kaz. (2024). Artificial Intelligence (AI)-Driven IoT (AIIoT)-Based Agriculture Automation. In Satapathy (Eds.), *Advanc. Computation. Metho. for Agri-Busine. Sustainabili.* (pp. 72-94). IGI Glob. <https://doi.org/10.4018/979-8-3693-3583-3.ch005>
21. Kazi & Saheb. (2025). AI-Driven-IoT (AIIoT)-Based Decision Making in Drones for Climate Change: KSK Approach. In *Aouadni, (Eds.), Rece. Theori. and Applicatio. for Multi-Criter. Decision-Maki.* (pp. 311-340). IG. Global.
22. Ka Ku. (2024). ChatGPT: An Automated Teacher's Guide to Learning. In *Bansal, & Rabby, (Eds.), AI Algorith. and ChatGPT fo. Stude. Engageme. in Onli. Learni.* (pp. 1-20). IG. Global.
23. Kat. (2026). Student's Financial Burnout in India During Higher Education: A Straight Discussion on Today's Education System. In Hai-Jew (Ed.), *Financi. Surviv. in High. Educati.* (pp. 359-394). IG. Global Scienti. Publishi.. <https://doi.org/10.4018/979-8-3373-0407-6.ch013>
24. Kazi, (2025). KSK Approach in LOVE Health: AI-Driven- IoT(AIIoT) based Decision Making System in LOVE Health for Loved One, *GRENZ. Internation. Journal of Engineer. and Technolo.*, 11(1), pp. 4628-4635.
25. Keerthana, R., K, V., Bhagylakshmi, K., Papnaidu, M., V, V., & Liakat, s. (2025). Machine learning based risk assessment for financial management in big data IoT credit. *SSR. Electron. Journ.* <https://doi.org/10.2139/ssrn.5086671>
26. Ku. (2023). Detecting Malicious Nodes in IoT Networks Using Machine Learning and Artificial Neural Networks, *Internation. Conference on Emergi. Smart Computi. and Informati. (ESCI)*, pp. 1-5, doi:10.1109/ESCI56872.2023.10099544. Available at: <https://ieeexplore.ieee.org/document/10099544/>

27. Kumar, P. Neeaja, R. G. M. S. Kumr, K. K. S. Liyaat and M. S. Vni. (2024), DL-Based Somnolence Detection for Improved Driver Safety and Alertness Monitoring. *Internation. Conferen. on Computi., Power and Communicati. Technologi. (IC2PCT)*, pp. 589-594, doi: 10.1109/IC2PCT60090.2024.10486714. Available at: <https://ieeexplore.ieee.org/document/10486714>
28. Kumar S. (2025). Scalable Internet of Things Enabled Intelligent Solutions for Proactive Energy Engagement in Smart Grids Predictive Load Balancing and Sustainable Power Distribution, *In Kannadhasan et al. (eds.), Proceedin. of the Internation.Conference on Sustainabili. Innovation in Computi. and Engineeri. (ICSICE 24), Advanc. in Comput. Science Resear. 120*, https://doi.org/10.2991/978-94-6463-718-2_85
29. Kut. (2024). IoT Driven by Machine Learning (MLIoT) for the Retail Apparel Sector. *In T. Tarnanidis, E. Papachristou, M. Karypidis, & V. Ismyrlis (Eds.), Driving Green Marketing in Fashion and Retail* (pp. 63-81). IGI Global.
30. Li (2025). KK Approach to Increase Resilience in Internet of Things: A T-Cell Security Concept. In Darwish, (Eds.), *Analyzi. Privacy and Securi. Difficulties in Soci. Media: Ne. Challeng. and Solutio.* (pp. 87-120). IGI Glob. Scientific Publishi..
31. Liy (2025). Healthcare Monitoring System Driven by Machine Learning and Internet of Medical Things (MLIoMT). *In P. Katina, (Eds.), Convergen. of Internet of Medic. Thin. (IoMT) and Generati. AI* (pp. 385-416). IG. Global Scientific Publish..
32. Liyakat. (2025). AI-Driven-IoT(AIIoT)-Based Decision Making in Kidney Diseases Patient Healthcare Monitoring: KSK Approach for Kidney Monitoring. In Özgür (Eds.), *AI-Driv. Innovati. in Healthcare Da. Analyt.* (pp. 277-306). IG. Global Scienti. Publish.. <https://doi.org/10.4018/979-8-3693-7277-7.ch009>
33. Muskan Ibram, Shikh A. Hakim A. Razzque, Heea T Shaih, Kzi. (2025). VHDL-Based Strategies for Protecting IoT Devices from Power and Electromagnetic Side-Channel Attacks: A Study. *Recen. Tren. in Electroni. & Communication Syste.. 12(3): 30–40p.*
34. More, R. J. Shine, K. P. Kondubhiri and S. S. Kable, (2025). AI-Driven IoT based Decision Making for Hepatitis Diseases Patient’s Healthcare Monitoring: KSK Approach for Hepatitis Patient Monitoring, *7th Internation. Conferen. on Intellige. Sustainab. Syste. (ICISS)*, pp. 256-263, doi: 10.1109/ICISS63372.2025.11076213.
35. Nayak K. Kast, N. Shakh, V. K. Rayabharau, and M. (2023). Implementation and Recognition of Waste Management System with Mobility Solution in Smart Cities using Internet of Things, *Second Internation. Conferen. on Augment. Intelligen. and Sustainable Syste. (ICAISS)*, pp. 1661-1665, doi: 10.1109/ICAISS58487.2023.10250690. Available at: <https://ieeexplore.ieee.org/document/10250690/>
36. Nerkar, P. M., Shide, S. S., SLiyaat, S. S., & SLiykat, V. S. (2025). Machine Learning for Brand Protection: A Review of a Proactive Defense Mechanism. *In Khan & M. Amin, (Eds.), Avoidi. Ad Fra. and Support. Brand Safe.: Programma. Advertising Soluti.* (pp. 175-220). IG. Global Scientif. Publish..
37. Patil, A. Galai, S. B. Khadak, K . K. B. Dhaale and S. D. Sark, (2025). AI-Powered-IoT (AIIoT) based Bridge Health Monitoring using Sensor Data for Smart City Management- A KSK Approach, *7th Internation. Conference on Intellige. Sustainable Syste. (ICISS)*, pp. 296-305, doi: 10.1109/ICISS63372.2025.11076329.
38. Pathan . M. Ibraim and K. K. Liyaat, (2025). Guardian Angel: An Innovative Mobile Application for Rapid Accident Notification and Emergency Response, *Advanc. Resear. in Analog and Digit. Communicatio., 2(3): 7-20.*
39. Pradeepa, M. (2022). Student Health Detection using a Machine Learning Approach and IoT, *2nd Mysore sub section. Internation. Conferen. (MysuruCon).* Available at: <https://ieeexplore.ieee.org/document/9972445>
40. **KEYTERMS:**
41. **Intelligent Pill Box:** Imagine a world where managing medication isn't a chore but a silent, supportive guardian. This is the promise of the **Intelligent Pill Box**, and understanding its components unlocks a new era of personal health management. At its core, the Intelligent Pill Box is more than just a plastic organizer; it's a connected device, a digital sentinel designed to ensure you never miss a vital dose.
42. **SM (Global System for Mobile Communications):** To understand this sentinel, we must first understand its language and its nervous system. The backbone of its connectivity lies in **GSM (Global System for Mobile Communications)**. Think of GSM as the cellular network that your smartphone uses to make calls and send texts. The Intelligent Pill Box leverages this ubiquitous technology to communicate wirelessly,

sending and receiving information without the need for Wi-Fi or complex setups. This allows it to operate independently, wherever a cellular signal can reach.

43. **e-mail:** This GSM connection enables a crucial communication channel: **e-mail**. While often associated with longer messages and attachments, in the context of the Intelligent Pill Box, e-mail serves as a reliable, albeit sometimes less immediate, notification system. It can be used to send comprehensive daily or weekly reports on medication adherence to a designated caregiver, doctor, or family member, providing a written record of compliance for their review.
44. **SMS Reminder:** However, for timely interventions, the Intelligent Pill Box relies on a more direct and immediate form of communication: **SMS Reminder**. Short Message Service (SMS) is the technology behind text messages. The Intelligent Pill Box, through its GSM module, can send these concise alerts directly to a user's or caregiver's phone. These aren't just generic nudges; they are precisely timed reminders, indicating exactly which medication needs to be taken and when, based on the pre-programmed schedule.
45. **Missed Dose Alert:** The true intelligence of the box shines through its proactive capabilities. One of its most vital functions is the **Missed Dose Alert**. If the pill box detects that a prescribed dose has not been taken within a specified window – perhaps the compartment for the morning medication remains closed – it will trigger an immediate alert. This could be an SMS to the user, a notification to a caregiver, or even a combination of both. This early warning system is critical for preventing the potentially detrimental effects of skipped medications, especially for individuals with chronic conditions.
46. **Emergency Notification:** Beyond just reminding and alerting about missed doses, the Intelligent Pill Box can also act as a lifeline through **Emergency Notification**. In situations where an individual might be incapacitated or unable to respond to a missed dose alert, the box can be programmed to escalate communication. If a missed dose alert goes unanswered after a certain period, or if certain sensors within the box detect unusual inactivity (perhaps indicating a fall or a medical emergency), it can automatically send out emergency messages to pre-selected contacts and, in more advanced models, even emergency services. These notifications can include the individual's location and vital pre-programmed medical information, potentially saving precious time in a critical situation.