

A Review on IOT Based Smart Medication Assistance System

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ABSTRACT

Medication non-adherence remains one of the most pressing challenges in modern healthcare, particularly among elderly patients and individuals managing multiple chronic conditions. Forgetting doses, taking incorrect medicines, consuming expired drugs, and improper dosage scheduling contribute significantly to treatment failure and preventable hospitalisation. The proposed paper proposes the **Smart Medication Assistance System (SMAS)**, which integrates an IoT-enabled automated pill dispenser with a dedicated mobile application for comprehensive medication management. The hardware features are a circular rotating dispensing mechanism with separate partitions per medicine, a real-time clock (RTC) module for time-accurate dispensing, a buzzer for audible alerts, and green/red LEDs for immediate visual dose-confirmation feedback. The companion Flutter application provides OCR-based medicine expiry scanning, refill reminders, alarm scheduling, and role-based caregiver access with a compliance dashboard. Together, SMAS empowers patients to self-manage medication while giving caregivers full remote visibility and control—offering a practical, low-cost, and scalable solution for home-based healthcare and improved patient safety.

Key Words: Smart Pill Dispenser; Medication Adherence; Caregiver Monitoring; Mobile Health; FCM(Firebase Cloud Messaging) Alerts; Real-Time Clock (RTC)

1. Introduction

Medication adherence is a cornerstone of effective treatment for chronic diseases, yet it remains poorly achieved globally. The World Health Organization estimates that approximately 50% of patients with chronic conditions fail to take medications as prescribed [2]. Non-adherence leads to disease progression, increased hospital admissions, and preventable deaths, costing healthcare systems hundreds of billions of dollars annually.

The problem is especially acute among elderly patients who often manage multiple prescriptions simultaneously, face cognitive decline, and may live alone without caregiver support. Common failure modes include forgetting scheduled doses, taking the wrong medicine from among several similar-looking tablets, using expired medicines, and incorrect dosage due to confusing instructions. Children and patients with disabilities also represent populations where reliable dose delivery is critical yet difficult to guarantee through manual methods alone.

Existing solutions span a wide spectrum. Simple pill organizers and alarms rely entirely on user memory and offer no verification that a dose was actually consumed. Commercial dispensers such as MedMinder and Hero Health address scheduling but are expensive, often exceeding \$100 in retail price, and lack intelligent health-state awareness or seamless caregiver integration. Recent prototypes have explored Arduino dispensers with buzzer alarms [1, 3], IoT-connected systems with mobile integration [10, 5], and smartphone apps with OCR-based prescription scanning [8, 9]. However, these systems typically address either the hardware dispensing problem or the software reminder problem—rarely both in a tightly integrated, affordable manner accessible to a broad patient population.

The proposed paper addresses these gaps with SMAS: a microcontroller-driven circular pill dispenser tightly coupled with a comprehensive mobile application covering expiry detection, refill reminders, alarm scheduling, medicine information, and role-based caregiver access. The key contributions of SMAS are:

- (i) a partition-per-medicine circular tray eliminating cross-medicine dispensing errors.
- (ii) dual-LED immediate patient feedback combined with FCM caregiver alerts for missed doses.
- (iii) on-device OCR expiry scanning with progressive three-tier alert escalation.
- (iv) a role-based mobile architecture unifying patient self-management with caregiver oversight.

2. Literature Survey

2.1 Hardware-Based Pill Dispensers

Chavan et al. [1] developed a circular-compartment dispenser using Arduino, RTC, IR sensor, and servo motor, demonstrating IR-triggered dispensing with minimal missed-dose events in a laboratory setting. Othman and Ek [2] proposed a Raspberry Pi-based smartphone-notified dispenser using the Insta-push notification service, supporting three compartments with on-screen popup confirmations. Rahman et al. [3] targeted physically disabled and elderly patients using multi-modal alerts including voice synthesis, LED arrays, and email notifications, combined with fingerprint biometric security at the dispenser lid. Daoud et al. [4] extended the concept by adding environmental sensors (DHT22 for temperature and humidity, MQ-4 for gas leakage) to verify safe drug storage conditions, and sent SMS alerts via the Blynk cloud platform on missed doses. Sadi et al. [5] deployed an IoT cloud-connected dispenser targeting elderly patients in rural settings, incorporat-

ing four-mode reminders (buzzer, LED, mobile push, SMS) and caregiver adherence analytics accessible through a web dashboard. Patil et al. [6] added fingerprint authentication to a NodeMCU-based dispenser, preventing unauthorised access and ensuring only the registered patient could retrieve medication. Deepan et al. [7] further explored voice-guided dispensing for elderly users with limited literacy, integrating a text-to-speech module directly with the hardware.

2.2 Mobile Applications and Software Systems

Dharmale et al. [8] proposed Vita Health, a mobile application that scans printed prescriptions via OCR, reads medicine names aloud through a text-to-speech (TTS) engine, and sends caregiver reminders via push notifications. The system demonstrated practical usability for semi-literate elderly users but lacked any coupled hardware component. Bhat et al. [9] developed a digital medicine assistant with hourly expiry notifications and colour-coded alert indicators (green/yellow/red), stored in an on-device SQLite database for offline access.

Shanthini et al. [10] integrated Firebase Realtime Database to synchronise a Flutter-based schedule manager with an Arduino dispenser, supporting both liquid and tablet dispensing modes and demonstrating near-zero synchronisation latency under typical home Wi-Fi conditions.

2.3 Expiry and Authenticity Tracking

Tomar and Tomar [12] proposed an SMS-based QR expiry reminder system using Twilio and Raspberry Pi, which also retrieved drug interaction and side-effect information from an online database. Rajeshwari et al. [13] developed MediScan, a QR-based anti-counterfeiting web application for detecting fake medicines at the point of purchase, providing a batch-level authenticity trail. Ganesh Kumar et al. [14] combined barcode scanning and ML Kit OCR for simultaneous grocery and medicine expiry tracking, reporting 100% alert delivery success across their test dataset.

Table 1 summarises the surveyed approaches and highlights the feature dimensions addressed by each prior work.

Research Gap: A review of the literature reveals that no existing system simultaneously integrates circular partition-based hardware dispensing, real-time dual-LED patient feedback, on-device OCR expiry detection with three-tier escalation, offline-resilient scheduling via EEPROM, and role-based caregiver access in a single cohesive and affordable platform. Individual prior systems excel in one or two of these dimensions but leave the remaining gaps unaddressed. SMAS is designed to fill all of them holistically.

3. System Design and Methodology

SMAS consists of two tightly coupled modules:

(A) a hardware pill dispenser with a circular rotating mechanism controlled by an ESP8266 microcontroller, and
(B) a Flutter mobile application for comprehensive medicine management and real-time alerts. Figure 1 shows the complete hardware dispensing control flow, and Figure 2 shows the mobile application interaction flow. Both modules communicate bidirectionally via Firebase Realtime Database, enabling schedule synchronisation, dispensing logs, and push notifications through a shared cloud backbone.

Table 1: Summary of Related Works

Ref	Author(s)	Method	Key Outcome
[1]	Chavan et al.	Arduino, RTC, Servo	IR-triggered dispensing
[2]	Othman & Ek	RPi, Insta-push	3-compartment; popup
[3]	Rahman et al.	NodeMCU, OLED	Multi-modal alerts
[4]	Daoud et al.	DHT22, MQ-4, Blynk	Environmental sensing
[5]	Sadi et al.	NodeMCU, IoT Cloud	Adherence analytics
[6]	Patil et al.	Fingerprint, Arduino	Secure dispensing
[7]	Deepan et al.	TTS, Arduino	Voice-guided dispensing
[8]	Dharmale et al.	OCR, NLP, TTS	Prescription scan+TTS
[9]	Bhat et al.	Android, SQLite	Hourly expiry alerts
[10]	Shanthini et al.	Firebase, Arduino	Firebase IoT sync
[12]	Tomar & Tomar	QR, Twilio, RPi	SMS expiry reminder
[13]	Rajeshwari et al.	QR, Web App	Anti-counterfeiting
[14]	Ganesh et al.	Barcode OCR	+ 100% alert delivery

3.1 Hardware Architecture

Circular Dispensing Mechanism. The dispensing unit uses a 3D-printed PLA circular tray with six equally spaced partitions, each dedicated to one medicine and capable of holding up to 30 tablets. The tray is mounted directly on the shaft of a stepper motor (28BYJ-48).

RTC and Feedback: A DS3231 RTC module provides battery-backed real-time date and time independent of microcontroller power state, ensuring schedule continuity even after brief power interruptions. On a schedule match:

- (1) the buzzer activates for 3 seconds;
- (2) the stepper rotates the tray to the target compartment;
- (3) a servo motor opens the dispensing aperture for the configured tablet count;
- (4) an IR sensor monitors collection within a configurable timeout window (default: 60 seconds);
- (5) successful collection illuminates the **green LED** and logs the event to Firebase;
- (6) failure to collect illuminates the **red LED** and dispatches an FCM missed-dose alert to the caregiver's registered device.

Connectivity and Resilience: The NodeMCU ESP8266 microcontroller uses its built-in Wi-Fi module for real-time bidirectional communication with Firebase Realtime Database. To handle intermittent internet connectivity, schedule data is also written to the NodeMCU's EEPROM, allowing dispensing to proceed autonomously during outages and syncing logs once connectivity is restored. Table 2 lists all hardware components and their roles.

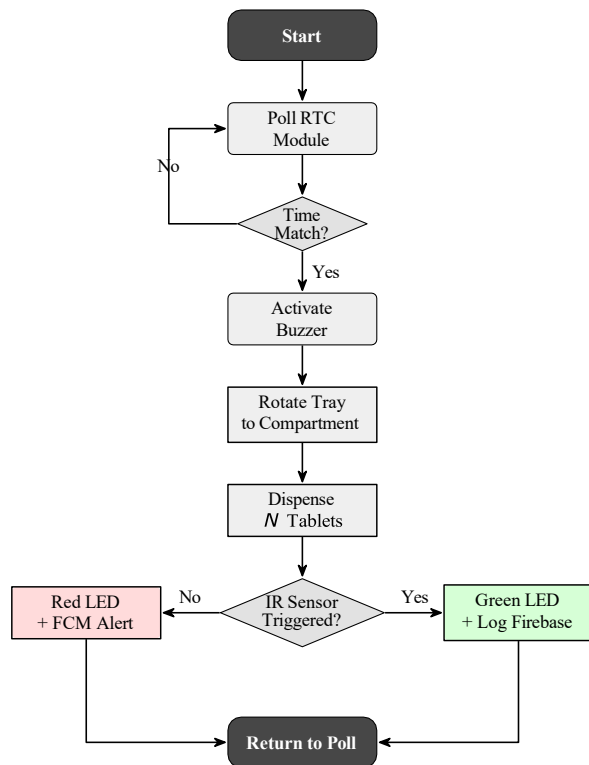


Figure 1: Hardware Dispensing Control Flow

3.2 Mobile Application Architecture

The Flutter application targets both Android and iOS and communicates with the hardware exclusively through Firebase Realtime Database, maintaining a shared real-time data mirror. Push notifications are dispatched through Firebase Cloud Messaging (FCM) for both missed-dose alerts and expiry warnings. Figure 2 shows the complete application interaction flow.

The application is structured around six integrated modules: **Medicine Registration:** Patients or caregivers register each medicine with its name, dosage strength, frequency, compartment assignment (1–6), and expiry date. Registered entries persist in Firebase and are mirrored to the hardware on next synchronisation.

Expiry Alert: The ML Kit Text Recognition API processes live camera frames entirely on-device and returns raw text blocks without requiring a network call. A regex pipeline parses three common date formats: DD/MM/YYYY, MM/YYYY, and MON YYYY. The extracted date is compared with the system clock and classified into three alert levels—*Safe* (>30 days), *Warning* (≤30 days), and *Expired* (past date)—reflected as green, yellow, and red indicators.

Refill Alert: Triggered automatically when the estimated remaining supply for any compartment drops below a configurable threshold (default: 5-day supply), preventing unexpected stockouts between caregiver visits.

Schedule Management: Caregivers configure the dispensing time, tablet count, and active days for each registered medicine. Changes are pushed to Firebase, from which the NodeMCU fetches and applies updated schedules in real time.

Caregiver Access: An elevated role permits schedule configuration, remote override of dispensing events, and access to

Table 2: Hardware Components of SMAS

Component	Role
NodeMCU ESP8266	Main MCU; built-in Wi-Fi for Firebase
RTC DS3231	Battery-backed real-time scheduling
Stepper (28BYJ-48)	Rotates tray to correct compartment
ULN2003 Driver	Drives stepper from logic levels
Servo Motor	Opens/closes dispensing aperture flap
IR Sensor	Detects tablet collection
Buzzer	Audible alert at dispensing time
Green LED	Confirms medication taken
Red LED	Missed-dose indicator
LCD 16×2 I2C	Displays time, medicine name, dose count

the full missed-dose history, while patients are restricted to a read-only view of their daily schedule and dose status.

Compliance Dashboard: Visualises adherence as daily, weekly, and monthly charts with per-medicine miss flags, giving caregivers an at-a-glance picture of patient behaviour over time.

4. Implementation Details

4.1 Medicine Scheduling and EEPROM Storage

At registration, caregivers provide the medicine name, compartment ID (1–6), dose count, scheduled times, and active date range. The NodeMCU writes schedule entries to both Firebase and local EEPROM so dispensing continues offline during internet outages. The EEPROM layout stores up to 24 schedule slots (four time-slots per compartment × six compartments). Each entry is a compact 5-byte record containing: compartment index (1 byte), hour (1 byte), minute (1 byte), tablet count (1 byte), and a validity flag (1 byte). On boot, the NodeMCU reads EEPROM first, then attempts a Firebase sync to apply any updates made via the app while the hardware was offline.

4.2 OCR-Based Expiry Detection

The Flutter app uses the Google ML Kit Text Recognition v2 API to process live camera frames on-device, requiring no internet connection during scanning. Recognised text is passed through a regex pipeline that sequentially attempts to match DD/MM/YYYY, MM/YYYY, and MON YYYY patterns. The first valid date match is extracted and compared against the device clock. Dates more than 30 days in the future are classified as *Safe* (green indicator), dates within 30 days generate a *Warning* (yellow indicator), and past dates are classified as *Expired* (red indicator). Progressive FCM alerts are dispatched at 30 days, 7 days, and on the expiry date itself, ensuring adequate time for medicine replacement. Scanned results are stored per compartment entry in Firebase for caregiver review.

4.3 Firebase Data Architecture

The Firebase Realtime Database is partitioned into three top-level nodes. /schedules stores medicine timing and dose configuration written by the mobile app and polled by

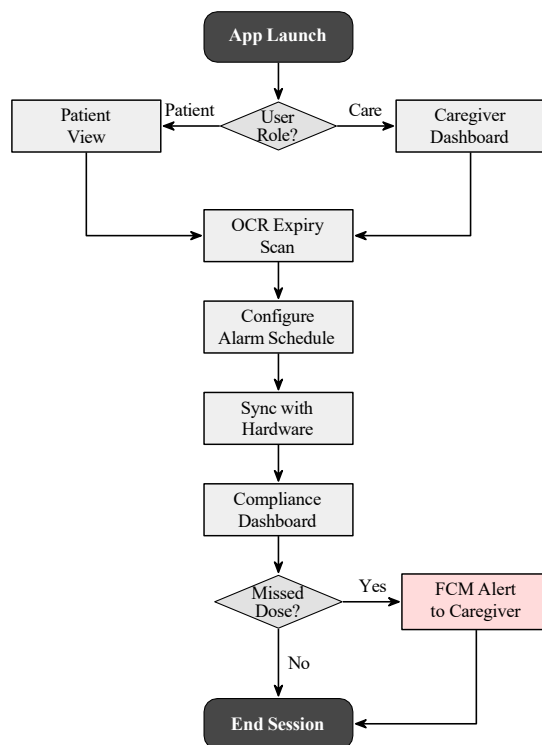


Figure 2: Mobile Application Interaction Flow

the NodeMCU at 5-second intervals. `/dispensing_log` records timestamped events for each dispense including the IR detection outcome, LED state, and tablet count delivered. `/alerts` holds active missed-dose and refill notifications consumed by the Flutter app to trigger outbound FCM messages. Firebase security rules enforce that only authenticated caregiver or patient UIDs can access their own data subtree, preventing any cross-patient data leakage. All Firebase connections use Transport Layer Security(TLS), ensuring data confidentiality in transit.

4.4 Power Consumption and Cost Analysis

SMAS is designed with affordability and energy efficiency as primary constraints. The complete hardware assembly—NodeMCU ESP8266, stepper motor, servo, DS3231 RTC, IR sensor, LEDs, buzzer—The complete hardware assembly uses commonly available off-the-shelf components, making the system highly affordable and significantly more economical than many existing commercial smart medication dispensers.

Power consumption is minimal. The NodeMCU draws approximately 80 mA during active Wi-Fi transmission and drops to <15 mA in modem-sleep mode between polling cycles. The stepper motor draws roughly 160 mA during rotation, with each dispense event lasting under 5 seconds. LEDs operate at 20 mA each. Under a typical four-dose-per-day schedule, total daily energy consumption is estimated at under 3 Wh, making SMAS suitable for continuous operation from a standard 5 V USB wall adapter or a 10,000 mAh power bank for portable deployment. Table 3 summarises the per-component power figures.

Table 3: Component Power Consumption Summary

Component	Current	Operating Mode
NodeMCU ESP8266	80 mA	Active Wi-Fi TX
NodeMCU ESP8266	<15 mA	Modem-sleep
Stepper 28BYJ-48	160 mA	Rotating (<5 s)
Servo Motor	150 mA	Aperture open/close
IR Sensor	20 mA	Continuous polling
LED (green/red)	20 mA	Active indication
DS3231 RTC	0.5 mA	Timekeeping

5. Observations and Insights

5.1 Current Limitations

- The circular tray accommodates six medicine types. Patients on complex multi-drug regimens exceeding six simultaneous medicines require a dual-tray extension or a redesigned higher-capacity mechanism.
- Irregular, oversized, or capsule-form tablets may not dispense reliably through the current aperture design; a wider adjustable funnel with jam-detection logic is needed.
- OCR accuracy degrades on severely degraded, reflective, or non-standard label formats. A QR or barcode fallback mode [14] would improve robustness for such edge cases.
- The system requires a functioning Wi-Fi network for schedule updates and FCM alerts. Rural or low-connectivity environments would benefit from an SMS-based fallback notification path.
- The current prototype lacks liquid medicine dispensing capability, which would be required for paediatric patients on syrup-form medications.

5.2 Strengths of the Proposed Approach

The partition-per-medicine design eliminates mixed-medicine dispensing errors and simplifies caregiver loading, a direct improvement over shared-compartment designs reported in prior work [1, 2]. Because each compartment holds a single medicine type, there is no risk of tablet mixing during the dispensing event, which is a common failure mode in open-tray designs. The one-rotation-per-dose paradigm is also mechanically robust; multiple partial rotations can extend the approach to higher tablet counts without redesigning the tray.

The dual-LED feedback scheme fills an important usability gap: most prior systems notify caregivers of missed doses [5] but provide no immediate patient-level visual clue at the point of dispensing. Green-and-red LEDs are universally interpretable without literacy and remain accessible to patients with cognitive or sensory impairments when paired with the audible buzzer, directly addressing the demographic studied by Rahman et al. [3]. Furthermore, the combination of an immediate physical LED and a delayed caregiver FCM alert creates a two-tier feedback loop that no single prior system provides.

On the software side, combining OCR expiry detection with progressive alert escalation, supply-level refill monitoring, configurable alarm scheduling, and role-based caregiver access in a single Flutter application is more comprehensive than any prior standalone app. Existing expiry apps [9, 12] treat this feature in isolation without linking it to a hardware

dispensing lifecycle; SMAS embeds it within a complete end-to-end medication management platform.

The EEPROM offline fallback is also a meaningful practical improvement. Systems relying purely on cloud connectivity [5, 10] will silently fail to dispense during network outages, which is a critical reliability risk in home settings. By caching schedules locally, SMAS continues correct dispensing and buffers dispensing logs for later sync, preserving the compliance record even during prolonged connectivity loss.

6. Future Work

Several planned improvements will extend SMAS both in hardware capability and clinical reach. In the near term, the hardware will be extended to a dual-tray configuration supporting twelve compartments, accommodating complex multi-drug regimens. Fingerprint authentication [6] will be integrated at the dispenser lid to prevent unauthorised access, particularly important in shared-household or paediatric settings.

On the software side, a text-to-speech module will be added to read the medicine name aloud at dispensing time, following the approach of Dharmale et al. [8] and addressing accessibility for low-literacy users. An SMS-based notification fallback will complement FCM for environments with limited smartphone access among caregivers. A wearable health-monitoring wristband measuring temperature, heart rate, and galvanic skin response (GSR), following Srimani et al. [11], will enable context-aware dispensing—for example, suppressing a dispensing event if the wristband reports that the patient is asleep, or escalating alerts if anomalous vital signs are detected coincident with a missed dose.

Clinically, a formal user study across a cohort of elderly patients in a supervised home-care setting will measure real-world adherence improvement, caregiver workload reduction, system uptime, and System Usability Scale (SUS) scores. The study will also inform calibration of refill and expiry alert thresholds and guide refinements to the compliance dashboard layout. Integration of QR-based anti-counterfeiting, as demonstrated by MediScan [13], represents a further complementary direction for ensuring medicine authenticity before the dispensing event.

Finally, exploring machine learning models trained on individual patient adherence patterns could enable predictive reminders—issuing alerts slightly earlier for patients who consistently collect doses late—further personalising the adherence support.

7. Conclusion

This paper presented the **Smart Medication Assistance System (SMAS)**, a dual-component solution combining an IoT-enabled circular pill dispenser and a comprehensive Flutter mobile application. The hardware uses a stepper motor-driven six-compartment circular tray with individual medicine partitions, a DS3231 RTC for time-accurate autonomous scheduling, an audible buzzer for dispensing alerts, and dual-colour LEDs for immediate patient-level dose-confirmation feedback. The mobile application delivers OCR-based expiry scanning with three-tier progressive alerts, configurable alarm schedul-

ing, supply-level refill monitoring, and a role-based caregiver access model featuring a compliance history dashboard.

SMAS directly addresses the primary root causes of medication non-adherence in an integrated, practical, and affordable package of hardware components. The system is well-suited for home-based elderly care, paediatric medication management, and community health clinic settings. The offline-resilient EEPROM schedule storage and two-tier LED-plus-FCM feedback loop represent specific advances over the prior art. Future extensions—dual tray, wearable health monitoring, voice output, SMS fallback, and formal clinical validation—will further increase real-world patient impact and deployment reach.

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References

- [1] N. Chavan, I. Chavan, S. Karkera, R. Samanta, and A. Birambole, "Design and Development of Smart Pill Dispenser," *Proc. SPICON*, IEEE, 2022, pp. 1–4.
- [2] N. B. Othman and O. P. Ek, "Pill Dispenser with Alarm via Smart Phone Notification," *Proc. IEEE GCCE*, IEEE, 2016, pp. 1–2.
- [3] Md. M. Rahman, R. Aktar, and S. K. Dey, "Design and Implementation of a Low-Cost Automated Medicine Dispenser," *Proc. ICAEEE*, IEEE, 2022, pp. 1–6.
- [4] H. Daoud, M. Daoud, N. Jardak, and C. Albouzidi, "Design and Implementation of Smart Pill Box for Healthcare Applications," *Proc. SSD*, IEEE, 2023, pp. 1046–1050.
- [5] S. S. Sadi, A. A. Tanvir, A. Al Hossain, M. F. Uddin, M. R. Uddin, and M. Hasan, "IoT-based Real-Time Medicine Reminder and Dispenser for Elderly Patients," *Proc. WCONF*, IEEE, 2024, pp. 1–5.
- [6] C. H. Patil et al., "An IoT based Smart Medicine Dispenser Model for Healthcare," *Proc. AIC*, IEEE, 2022, pp. 391–395.
- [7] P. Deepan, J. P. Hemavarshini, P. Kowsalya, and C. Rajasekaran, "IoT based Intelligent Pill Dispenser for Elderly People," *Proc. ICPCSN*, IEEE, 2023, pp. 951–955.
- [8] G. Dharmale et al., "Vita Health – A Complete Healthcare System," *Proc. INCET*, IEEE, 2023, pp. 1–4.
- [9] S. S. Bhat, B. A. S, S. K, and S. S. Rao, "Digital Medicine Assistant – Health Application for Expiry Tracking," *Proc. CENTCON*, IEEE, 2021, pp. 279–284.
- [10] M. Shanthini et al., "Design and Implementation of IoT based Automatic Medicine Dispenser," *Proc. ICIMIA*, IEEE, 2023, pp. 24–28.

- [11] S. Srimani, R. Banerjee, D. Chatterjee, and S. Jana, "MedTech: An IoT based Pill Dispenser and Health Monitoring System," *Proc. IEMENTech*, IEEE, 2026, pp. 1–6.
- [12] I. Tomar and B. Tomar, "A Smart Expiry Date Reminder System For Medicines," *Proc. ICIERA*, IEEE, 2021, pp. 1–6.
- [13] J. Rajeshwari et al., "MediScan – Know Before You Dose," *Proc. CSITSS*, IEEE, 2025, pp. 1–6.
- [14] G. K. G, V. V, A. K. P. R, and R. N. M, "Smart Tracker: An Automated System for Tracking Expiry Dates," *Proc. ICMSCI*, IEEE, 2026, pp. 1685–1689.