CureCue: A Smart Adherence Assistant and Reminder System

CureCue is an intelligent tool that leverages cutting-edge technology to transform the landscape of patient self-care. From ensuring medication safety with the Expiry Date Checker to aiding in prescription reminders via the Adherence Assistant, our application provides excellence in healthcare.

Authors

1. Puneet, IIT Madras
2. Pranshu Jaiswal, IIT Madras
3. Saransh Saini, IIT Madras
4. Neelesh S. Upadhye, Department of Mathematics, IIT Madras

Executive Summary

Non-adherence to medication is a persistent global issue. It contributes to treatment failures, hospitalizations, and other health complications. It is particularly prevalent in the elderly and the visually impaired. The existing reminder apps require manual logging and active user participation. This eventually leads to limited adoption across users and creates friction in the process. CureCue can help to bridge this gap with an end-to-end, AI-powered adherence assistant. It simplifies and automates the medication tracking process through natural speech and image-based interactions. We have come up with a handy, mobile solution that integrates real-time STT (speech-to-text), computer vision, OCR, and LLMs, delivering a user-centric and accessible system. The key features include automatic detection of names, expiry dates via image capture, extraction of medicine dosage through voice commands, timely notifications, no reliance on the internet, and a lightweight deployable architecture. The performance of CureCue is based on rigorous evaluation: YOLOv8 has 92.3% mAP@0.5 for expiry date detection. PaddleOCR has 93% accuracy on clear regions and 87.3% on cluttered names. Our system depicts strong commercial potential in the future emerging and existing developed healthcare market. We offer scalable impact and efficiency in personal medication management.

Introduction and Motivation

Medication non-adherence is a major contributor to treatment failure and increased hospitalization rates worldwide. Human error, forgetfulness, and difficulty understanding dosage instructions are leading causes of such problems. The elderly and the visually impaired are affected the most.

Current solutions—reminder apps and manual logs—rely on precise user input. This often leads to impediments in widespread adoption. There is a scarcity of better and smarter tools with minimal interference to seamlessly incorporate into their lifestyles.

It has been estimated by the World Health Organization (WHO) that almost 50% of the people suffering from chronic diseases fail to adhere to their prescribed medicines[1][2]. This figure is even higher in underdeveloped nations. These seemingly harmless acts of non-adherence drive up morbidity, mortality, and healthcare costs. In the United States alone, medication non-adherence is associated with more than 100,000 deaths annually and accrues costs up to $529 billion[2][8][13]. Several factors contribute to medication non-adherence, such as forgetfulness, complicated medical regimens, and even socioeconomic barriers[4][10][15]. In India, it was observed in a study that the average medication adherence rate among people with non-communicable diseases was a whopping 51%[5][11]. The study was about analyzing WHO's SAGE2 survey data. The study also brought into account that multimorbidity, tobacco prevalence, and limited formal education were significantly associated with non-adherence. Furthermore, when chronic diseases such as diabetes, hypertension, and cardiovascular conditions, etc, are prevalent, then non-adherence poses an extremely greater risk to the patients.[5][10].

There have been multiple efforts to improve non-adherence among patients. Efforts included patient education, counseling, simplified dosing regimens, and the use of digital health gadgets such as electronic reminders and mobile applications[7][9][12]. Lately, the expert reviews have made claims that digital tools such as reminder applications and smart notification systems have made positive impacts on the adherence rates, given that they were heavily tailored to the individual's needs[9][20]. However, despite all these advances in medical technology, there exists no universal solution, and other systems are required to adapt to specific cohorts of people and their healthcare needs[1][15]. There exists a very critical impediment to medication adherence in the context of serious chronic diseases worldwide. To mitigate these issues, there is an immediate necessity for a multidimensional approach that can incorporate all diverse factors influencing patient behaviours and can leverage both traditional and digital strategies to promote adherence.

To address these shortcomings, we have built the Adherence Assistant & Expiry Date Checker, a mobile application that integrates multiple AI-powered pipelines to help users. Key features include:

- Identify and extract medicine names.
- Capture, digitize, and systematically store the expiry dates from medicine packaging.
- Support speech-based input mechanisms and extract meaningful information such as the medicine name, number of doses, and time of dosage.
- Set reminders automatically and notify users via push notifications.

This paper outlines a comprehensive overview of the system architecture, methodological framework, performance analysis, and future work. We plan to showcase that combining pipelines of real-time computer vision with speech recognition and natural language processing can alleviate the cognitive and mental workload faced by patients.

System Architecture and Methodology

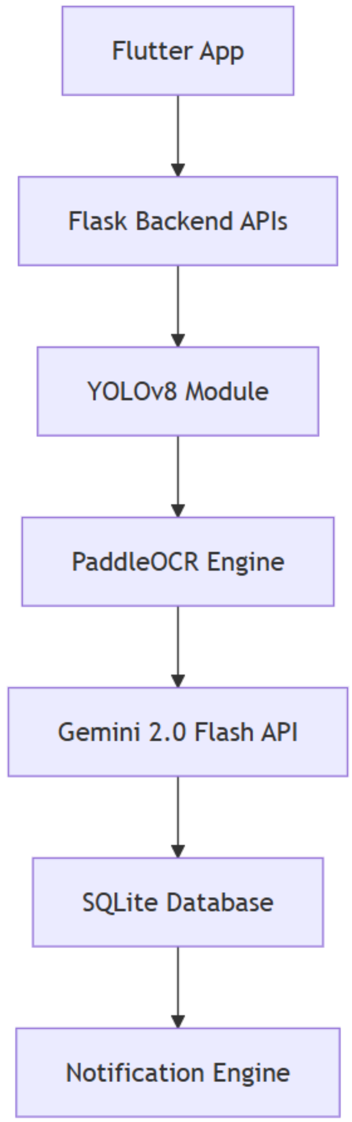

Fig 1. Overall System Architecture

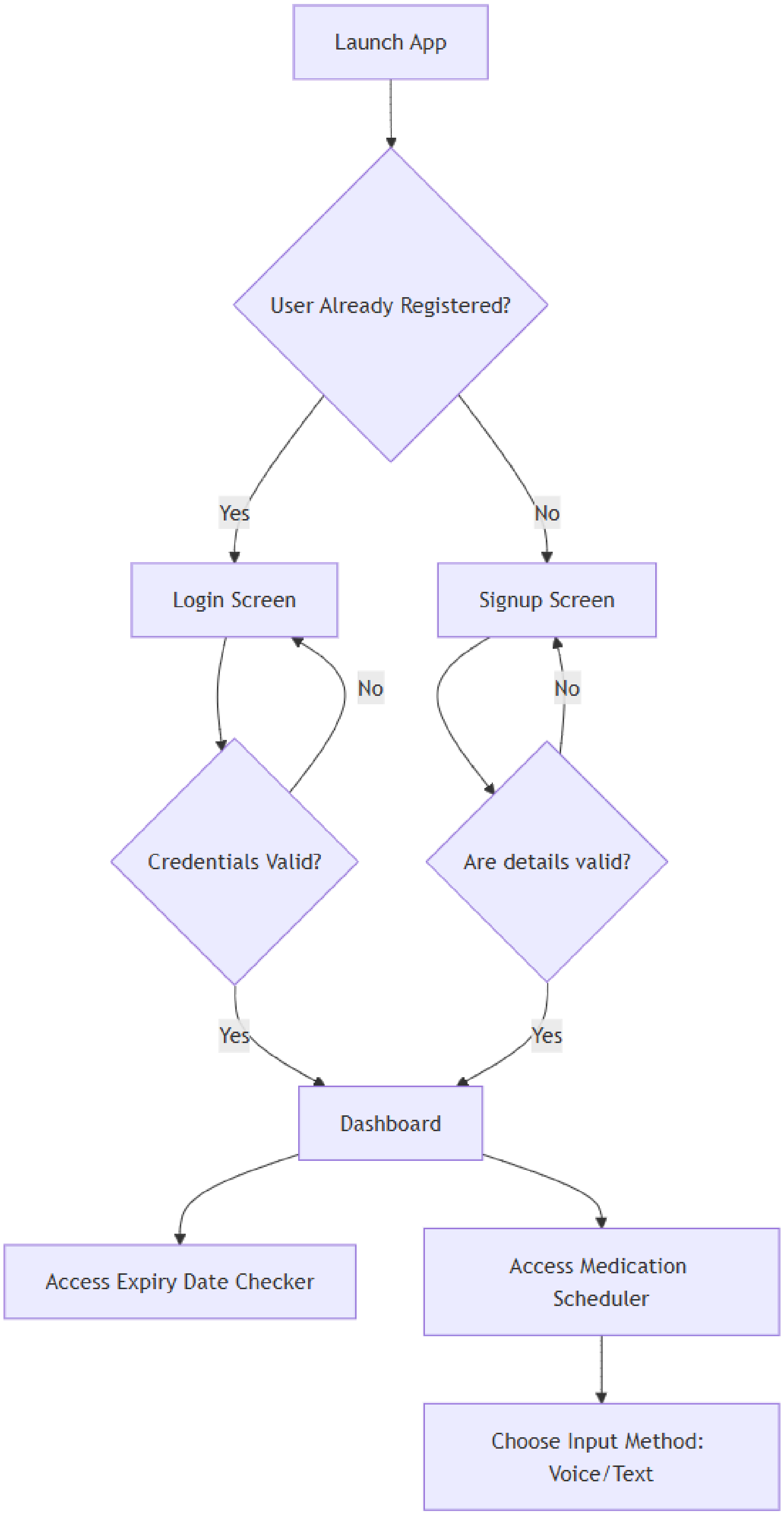
Launch App
User Already Registered?
Yes
No
Login Screen
Signup Screen
No
No
Credentials Valid?
Are details valid?
Yes
Yes
Dashboard
Access Expiry Date Checker
Access Medication Scheduler
Choose Input Method: Voice/Text

Fig 2. Mobile Application Workflow

The application is built on a robust foundation of five integral components. Each component seamlessly works together to facilitate a good user experience in medication management. The architectural framework ensures accuracy, accessibility, and active support for all users.

Image Capture Interface

The Android application starts with one of the most basic functionalities, which is the Image Capture Interface. It was developed using the Flutter framework. The interface enables users to effortlessly capture high-quality images of medication names and expiry dates. The image is then sent over to the expiry date detection/medication name detection module.

Expiry Date Detection

After an image is captured, the Expiry Date component springs into action within the Flask backend APIs. This module leverages the YOLOv8 (You Only Look Once version 8), a state-of-the-art object detection model known for its exceptional accuracy and speed in identifying and localizing objects within images. The YOLOv8 model precisely draws bounding boxes around potential date regions on medication packaging. After the formation of the bounding boxes, these date regions are then cropped and isolated and forwarded to the PaddleOCR component.

Text Extraction using PaddleOCR

The cropped image(s), which now contain the isolated date(s), are fed into the Text Extraction using the PaddleOCR component. PaddleOCR is a highly effective and reliable optical character recognition tool. The application uses PaddleOCR in two separate pipelines:

- **Expiry Date Extraction:** This is the primary usage of PaddleOCR in our application. The given cropped image(s) are processed by PaddleOCR to convert the visual characters into machine-readable text. There exists a layer of logic that can handle a wide variety of date formats, for instance, dates containing different separators and different month representations, or different year formats. The accuracy of this extraction is the most critical, as even a small deviation has the potential to cause life-threatening conditions.
- **Medication Name Extraction:** Besides the medicine expiry date, PaddleOCR is also pivotal in extracting medication names from medicine strips. In this case, bounding box detection is not done; rather, the application processes broader regions of the package to identify all text. All the given texts are then passed along to Google's Gemini 2.0 Flash, which then identifies which word is the medication name and then returns that as output.

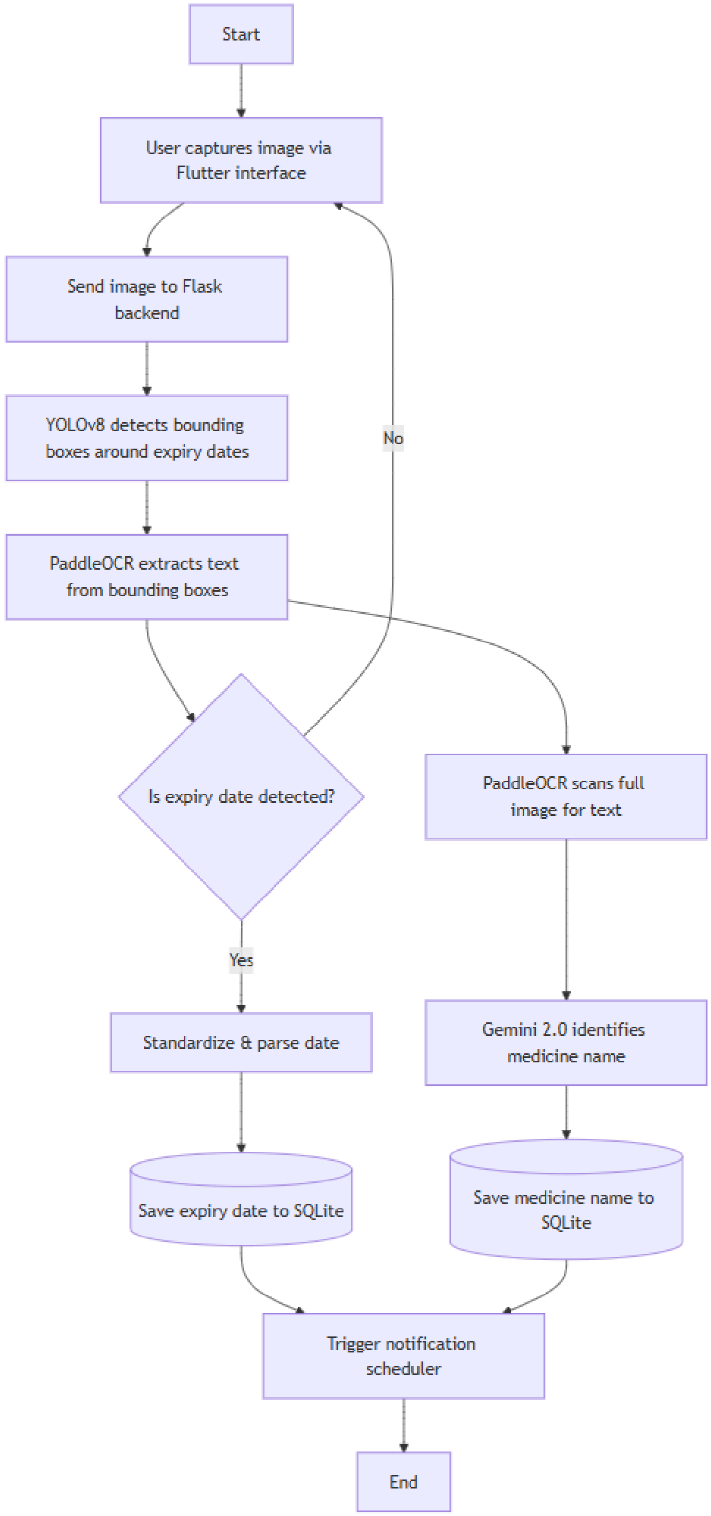

Fig 3. Medication Name and Image Processing Workflow

Voice Command Parsing

For the sake of better accessibility and a truly hands-free experience, the application supports the Voice Command Parsing component. With this feature, users can intuitively interact with the application by speech commands about their medication tracking and reminders. For instance, if we consider this input, “I want to take paracetamol after dinner on every alternate day”. The goal is to extract information such as the medicine name, number of times, and days. We have successfully solved this with a pipeline involving a native Android Speech-To-Text (STT) model along with Google Gemini’s 2.0 Flash model. This cutting-edge LLM is specifically chosen for its reasoning and speed capabilities, making it best suited for our real-time tasks. Gemini, after receiving the raw text, returns a structured output that is used by the application for scheduling medication reminders.

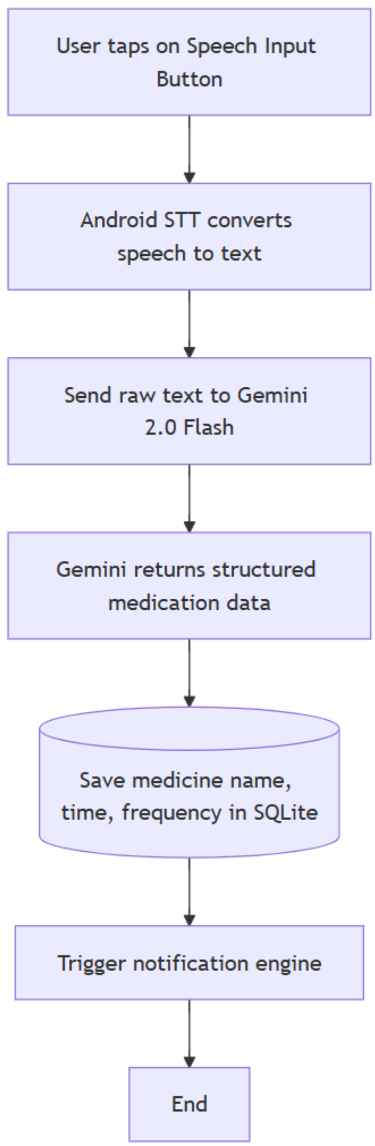

Fig 4. Voice Command Workflow

SQLite Storage and Notification Engine

All the extracted and compiled data is then systematically stored in our SQLite database, which is used by the notification engine accordingly. All the information, such as medicine name, dosage frequency, dosage times, and expiry date, is stored locally in the user's mobile device. SQLite is chosen for its lightweight nature, serverless architecture, and robust performance.

After the proper storage of the data, a cutting-edge notification manager is utilized, which functions as an overseer of the medication adherence of the user. It provides smart push notifications based on the frequency and exact times of dosages, which are extracted from the input methods. It also takes into account all days of the week, specific meal times, and other user-defined parameters. This approach crucially improves medical adherence among users by a lot.

Performance Analysis

The application's efficiency and reliability are reinforced by meticulous validation tests done throughout the development cycle. Custom benchmarks and real user testing have been used to provide solid quantitative insights about the performance of each module of the application.

Expiry Date Detection (YOLOv8)

The application's expiry date module has at its core the YOLOv8 model. The model was trained extensively on a dataset from Roboflow, which consisted of almost 1700 carefully curated images of expiry dates in packaging in various lighting conditions.

The performance metrics showed promising results:

mAP@0.5*	92.3%
mAP@0.5-0.95*	86.6%
Average Detection Time*	<0.9s

Text Extraction (PaddleOCR)

The textual extraction capability of the system is powered by PaddleOCR. Its accuracy has been evaluated across different types of texts encountered in medications. Similar to YOLOv8, PaddleOCR also shows promising results.

1. Clear Expiry Dates
    - Accuracy*: 93%
    - F1 Score*: 91.5%
    - Precision*: 92%
    - Recall*: 91%
2. Cluttered Medication Names
    - Accuracy*: 87.6%
    - F1 Score*: 86.8%
    - Precision*: 88%
    - Recall*: 85.7%

As you can notice, there are some OCR misclassifications typically occurring in low-contrast images or specialized or styled fonts. We tried to mitigate this problem using basic preprocessing using REGEX patterns and post-OCR filtering heuristics (based on similarity index).

Voice Command Understanding (Voice + Gemini 2.0 Flash)

The robustness of the voice-driven scheduling was assessed manually. We annotated 120 voice commands across 10 users (12 each) that specifically contained medication names, dosage frequency, and times. We noticed that failures occurred when the commands were completely ambiguous or lacked a specific dosage time. The following results were observed.

- Intent Extraction Precision*: 94.1%
- Entity Recognition Recall*: 92.3%
- F1 Score: 93.2%

Pilot Case Study: 30 Users Adherence Uplift

We performed a pilot case study over 14 days that involved 30 users, who were aged between 17 and 62 years. The users were split equally between two groups -

- Control Group* (they used the Standard Alarm App)
- CureCue Group* (they used our system, which has all the features enabled)

The following results were observed:

- Average Missed Doses/User:
    - Control: 5.2
    - CureCue: 1.6

- Adherence Uplift under Observance:
  - Approximately 69% improvement in dose adherence.
  - As per the feedback received from the users, speech reminders and expiry alerts were the most helpful features for them.

Privacy, Compliance, and Fairness

The system design of CureCue ensures data privacy and equitable performance across various tested demographics. We process all sensitive user data (like medicine name, dosage time, audio recordings, and expiry dates) locally on the users' devices. No personally identifiable information (PII) or health records are transmitted in any form to external servers, not even on our server. We have completely made our system internet-free; there is no reliance on cloud storage. The system works on an on-device SQLite database and native processing on the users' smartphones. CureCue complies with GDPR's data minimization, HIPAA's minimum necessary standards, and user content principles. We also provide the option to delete the user data directly from the device in just one click.

We have evaluated CureCue's voice understanding pipeline (Gemini 2.0 + STT) for age, language, and accent variance with the help of a curated dataset with 18 diverse speakers.

- Age Range: 18 - 65 years
- Accents: Indian (North/South), American, British, and Neutral.
- Languages Used in the Commands: English (India, US, and UK), Hinglish

We tested it across 90 test commands:

- Parse F1 Score (young vs elderly): 92.1% vs 89.3%
- Accent Robustness F1: 93.5% (Indian), 91.2% (American), and 90.7% (British)
- Language Mixing (Hinglish) F1: 87.9%

These results prove that CureCue has great and reliable performance across diverse user groups. The efforts are still ongoing to improve multilingual and low-literacy usability.

Deployment

The architecture of CureCue follows the philosophy of user-first, accessibility priority, speed, and entirely offline functionality. The deployment strategy revolves around a very lightweight Android application that is built on the Flutter framework. This helps ensure cross-platform compatibility on iOS, Wear OS, and Android devices. The application’s core functionality is entirely on-device and uses SQLite for local storage. This eliminates dependence on cloud-based services or internet connectivity. These design choices help improve accessibility across the country, specifically in rural or bandwidth-constrained areas. Additionally, it significantly enhances the privacy and security of user data. The application package has a built-in YOLOv8 and a PaddleOCR module that is heavily optimized for mobile deployment. These models were compiled and quantized using relevant datasets to reduce latency and footprint. It ensures efficient execution on any low or mid-tier smartphone. The voice command module integrates the native Android STT (Speech-To-Text) service, and it is additionally paired with Google's Gemini 2.0 Flash model. It provides an on-device inference module, thus making the process a real-time interaction smooth and trustworthy.

A custom notification engine operates locally, thus handling the dynamic scheduling of reminders. It is based on user voice input and information extracted from the voice. The deployment process includes bundling all the AI models within the binary application layer. It does not require any additional downloads post-installation. The APK package for Android has been tested on various device configurations to ensure broader compatibility. During the pilot phase, users appreciated the intuitive experience and smoother interaction, and showed great improvement in adherence. In the future, we plan to distribute the CureCue application via the Google Play Store and the Apple App Store. We will ensure that the application follows all the necessary compliance checks and regional data policies to maintain wide-scale adoption.

Conclusion and Future Work

Our CureCue application provides a transformative approach to tackle the longstanding challenge of medication non-adherence. The system has combined computer vision, OCR, speech recognition, and large language models. It delivers an accessible and intuitive experience for various age groups and literacy levels. The traditional reminder apps were heavily dependent on manual inputs. Whereas, the CureCue automates the entire process to detect expiry dates, extract medicine names, and generate smart reminders. The architecture is offline-first, lightweight, and maintains end-to-end user privacy to ensure reliability. We have observed that the system has high performance across various testing scenarios, including voice commands, adherence improvement, OCR extraction, and multilingual support in pilot studies. It highlights its practical effectiveness and scalability. The CureCue reduces the cognitive burden on the user's part. We empower and help users to manage their health responsibly and independently. In the future, our application is poised to become a comprehensive medication management platform. We have several future expansions in the pipeline that include multilingual voice support, real-time analytics, prescription voice sync, and a smart escalation system. We aim to bridge the gap between healthcare accessibility and technological innovation. Thus, offering a compelling solution for a global problem.

The CureCue application currently provides a comprehensive adherence assistant along with the expiry date checker. We have several additional plans to extend the product capabilities. We aim to add Hindi and other regional languages to serve rural and semi-urban regions of India. Another promising feature we intend to build in the future is voice-enabled prescription sync. It would allow the doctors to record prescriptions verbally. The application will process the audio, extract relevant details, and auto-populate the prescription form. Next, we plan to build a centralized analytics dashboard for users and their caregivers. The dashboard will visualize the adherence patterns, missed dosage, medication history, etc, in real time. It would help in self-awareness and early intervention (if required). In sync with this, we plan to have a smart alert escalation mechanism, where if the doses are missed repeatedly, it will trigger the notification to the emergency contact number added by the user. Lastly, we envision embedding a contextual question mark icon beside the listed medicines. When tapped, the application layer will invoke an agentic Gemini model to provide concise summaries and additional relevant information about the same. By implementing these changes, the application will be ready to empower users with better decision-making and improve health literacy. We are building some of the features from the ones listed above. The full-fledged product will be released soon.

References

1. Kardas, P., et al. "Medication non-adherence: reflecting on two decades since WHO adherence report and setting goals for the next twenty years." (2024).
2. PAN Foundation. "Medication non-adherence: a common and costly problem." (2023).
3. AlHewiti, A. "Medication adherence among patients with chronic diseases." (2014).
4. Tolley, C., et al. "Factors influencing adherence to non-communicable disease medication in India: secondary analysis of cross-sectional data from WHO - SAGE2." (2023).
5. Abbott. "Strategies to improve adherence to medication." (2025).
6. Core Prescribing Solutions. "The Economic Burden of Medication Non Adherence." (2024).
7. AllazoHealth. "5 Medication Adherence Tools that Improve Patient Outcomes." (2024).
8. Mekonnen, A.B., et al. "Factors influencing poor medication adherence amongst patients with chronic disease in low-and-middle-income countries: A systematic scoping review." (2022).
9. British Geriatrics Society. "Factors influencing adherence to chronic disease medication among older adults in India: analysis of SAGE2 survey data."
10. Bosworth, H.B., et al. "The new landscape of medication adherence improvement: where population health science meets precision medicine." (2018).
11. Cutler, R.L., et al. "Economic impact of medication non-adherence by disease groups." (2018).
12. Jimmy, B., & Jose, J. "Medication Adherence Measures: An Overview." (2011).
13. University of Cambridge. "Factors influencing adherence to non-communicable disease."
14. Kardas, P., et al. "Medication adherence influencing factors—an (updated) overview of systematic reviews." (2019).
15. Vrijens, B., et al. "European Network to Advance Best Practices and Technology on Medication Adherence: Mission Statement." (2021).

*Appendix A

This appendix aims to define all the key performance indicator metrics and research framework terms referenced in the CureCue system paper. Each topic below is a term and includes a brief description and its relevance to our case.

- **mAP@0.5 (Mean Average Precision at IoU Threshold 0.5)**
  - **Definition:** Mean Average Precision at IoU >= 0.5 is a performance metric for object detection tasks. It evaluates the correctness of the bounding boxes predicted that overlap the ground truth by at least 50%.
  - **Usage in CureCue:** It was used to evaluate the performance of the YOLOv8 model, which was trained to detect expiry dates on medication packaging. The higher the mAP@0.5 is, the more reliable the expiry date detection is.
- **mAP@0.5:0.95**
  - **Definition:** This metric averages the Average Precision scores across IoU thresholds from 0.5 to 0.95 (in steps of 0.05). It is used to represent an even more stringent measurement of classification and object localization.
  - **Usage in CureCue:** It is an even more holistic evaluation of the YOLOv8 model's performance in detecting expiry dates in unfavourable conditions.
- **Average Detection Time**
  - **Definition:** The average time it took in milliseconds for the YOLOv8 model to take an image as input, process it, and then return the image with bounding boxes.
  - **Usage in CureCue:** It is measured to ensure the efficiency of the model in the mobile application. Real-time output is crucial for the usability of the mobile application.
- **Accuracy**
  - **Definition:** Indicates the performance of the model by the ratio of true results and total results.
  - **Usage in CureCue:** It was used in the classification module for verification of the valid and invalid expiry date formats.
- **Precision**
  - **Definition:** It is the measure of the number of true positive results to the ratio of the number of all positive predictions.
  - **Usage in CureCue:** High precision is a key metric used. It is used to ensure only valid expiry dates are extracted.
- **Recall**
  - **Definition:** It is the ratio of the total number of true positives detected to the sum of true positives and false negatives.
  - **Usage in CureCue:** It is a critical evaluation metric of the expiry date detection.
- **F1 Score**
  - **Definition:** It is the measurement of the harmonic mean of precision and recall.

- **Usage in CureCue:** It is one of the key metrics that can reliably show the model's performance in the detection of expiry dates.

- **Intent Extraction Precision**
  - **Definition:** It is used to measure the veracity of the system in identifying the user's intent from their speech input.
  - **Usage in CureCue:** This was used in the voice input system module powered by Android Speech-To-Text and Gemini 2.0 Flash API. For instance, if the sentence uttered by the user was "I want to take paracetamol on alternate Fridays from next week after dinner at 7 pm," the intent is "schedule a notification reminder on every alternate Friday at 7 pm", which is inferred by the Gemini 2.0 Flash LLM model.
- **Entity Recognition Recall**
  - **Definition:** It is an evaluation metric to measure how good the system is at capturing the required entities, such as medicine name, dosage time, etc, from the given speech input.
  - **Usage in CureCue:** It was used to measure and evaluate Gemini 2.0 Flash's ability to understand and return the entities from voice input.
- **Control Group**
  - **Definition:** It is a group of people who use the beta or first version of an application for future comparison purposes.
  - **Usage in CureCue:** This group of users used traditional reminders and alarms for medical adherence. It was used as a benchmark.
- **CureCue Group**
  - **Definition:** The experimental group of users who used the CureCue application with all its features.
  - **Usage in CureCue:** This group of users used our CureCue mobile application for various purposes, such as medication adherence and all other components. The performance of this group, along with the Control Group, was compared to understand the adaptability and utility of CureCue in real-world cases.