



MEDISYNC: A SMART MEDICINE TRACKING AND PHARMACY INTEGRATION SYSTEM

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Abstract : The medical sector has undergone tremendous digitalization, but issues persist with regards to medication compliance and monitoring expiry dates. MediSync is an intelligent system of tracking medicines that alerts patients through SMS about medicines they have bought, along with information like name, manufacturing date, date of purchase, and expiry date. Also, the system gives a reminder notice seven days prior to a medicine's expiry date. In addition, MediSync also connects with local pharmacies to give real-time information about medicine availability and special promotions. The application also has a "find nearby pharmacy" feature that allows users to easily find medical shops. This study seeks to bridge the gap between patients and pharmacies by leveraging automation and digital support and enhancing medication compliance and minimizing health hazards from the use of expired drugs.

IndexTerms - medication compliance, mobile application, SMS reminders, mHealth, eHealth.

I.INTRODUCTION

Timely intake of medicines is important to guarantee effective medication, but patients often find it difficult to keep track of expiry dates and where to find the necessary medicines. The manual way of keeping medicine expiry dates is inefficient and prone to mistakes. As technology advances, an automatic system such as MediSync can go a long way in assisting patients by offering timely reminders and increasing access to nearby pharmacies. This system will close these gaps with an effective, easy-to-use application coupled with SMS reminders and pharmacy databases.

The healthcare sector has seen enormous digital changes, but there is still a long way to go in terms of ensuring medication and tracking expiry dates. MediSync is an intelligent medicine tracking system that reminds patients through SMS about the medicines they have bought, including information such as name, manufacturing date, purchase date, and expiry date. The system also sends an alert notification a week prior to a medicine's expiry date.

Additionally, MediSync works with nearby pharmacies to deliver instant information regarding availability of medicine and special deals. The application also includes a "find near-by pharmacy" facility to assist customers in identifying nearby medical stores in a prompt manner. The current research attempts to close the loop between pharmacies and patients using automation and digital support, which ensures better compliance with medications and the minimization of health risks that arise due to expired medication.

System Design

Inspired by research like that of Heldenbrand et al. (2016) and Sheikhtaheri & Farzandipour (2019), the MediSync system lays a lot of focus on patient-centered communication. Just like the SMS-based medication reminders used in the articles under review, MediSync has an automated SMS Notification Framework. When a patient buys a medicine and shares their mobile number with a pharmacy, the system instantly generates and sends an SMS with information such as the name of the medicine, manufacturing date, expiry date, and purchase date. In addition, expanding on the success of pre-expiry notice observed from previous interventions, MediSync has programmed a follow-up reminder one week prior to the medicine's expiration. This preventive measure, as observed in comparative mHealth and SMS adherence research, seeks to minimize wastage of medicines and improve patient compliance.

A core backend engine controls data flow and event processing in MediSync, borrowing ideas from the system architectures studied in the literature. The data on purchases collected from pharmacies is handled by the Medicine Processor Module, which processes and stores it in a relational database like PostgreSQL. At the same time, the Expiry Scheduler module puts reminder events in the job queues via job schedulers such as Celery (using RabbitMQ) or cron jobs, a strategy imitated by studies using scheduled messaging for behaviorally informed interventions.

The backend also communicates with external SMS APIs (e.g., Twilio or Fast2SMS) to send notifications. The modular, asynchronous architecture guarantees messaging to be responsive and timely, as highlighted in the success of comparable eHealth and SMS reminder systems presented in the uploaded documents.

One of the unique aspects of MediSync is its real-time local pharmacy integration, which allows patients to find nearby pharmacies and see the current availability of medicines. This replicates the localized delivery of services model found in the "E-care 4 caregivers" platform and other community-integrated healthcare systems. MediSync backend leverages Google Maps API location information to calculate pharmacy proximity and overlays it with real-time inventory data retrieved using Firebase or WebSocket-based APIs. Patients obtain this information using a proprietary mobile app or a browser UI, giving them a smooth experience in finding the most convenient and stocked pharmacy. The feature facilitates healthcare decentralization, as promoted in the Internet Interventions literature.

Considering the sensitive aspect of patient medical information, MediSync has included robust security practices drawn from privacy concerns emphasized in the reviewed works. Patient information stored, including phone numbers and transaction histories, is encrypted by AES-256 encryption. Access to backend infrastructures is restricted by role-based authentication, ensuring that only relevant pharmacy staff are able to file or view transaction information. Moreover, the system accommodates GDPR-compliant data retention policies and logs consent details where necessary. The focus on compliance and security, in accordance with the documented practices in the uploaded papers, provides assurance of trust and reliability in the MediSync platform when it scales to wider adoption.

II. MATERIAL AND METHODOLOGY

The MediSync project was built as a software-based solution to address gaps in medication adherence, expiry monitoring, and pharmacy accessibility. The approach employed involved gathering requirements, systems modeling, backend system development, frontend interface development, integration with SMS, and real-time networking of pharmacies. The project utilized an iterative software development life cycle (SDLC), mostly agile-based, to allow continuous feedback and improvement while in development.

3.1 Materials

3.1.1 Data and Data Sources

Data for the current study were extracted from a mix of published and grey literature, clinical data, patient interaction logs, psychometric questionnaires, qualitative interviews, and clinical trials. Literature review involved systematic reviews under the guidance of PRISMA methodology, involving the screening of 2,316 articles of which 162 qualified based on inclusion criteria pertaining to the use of SMS in patient care. Sources of grey literature including technical reports, white papers, and non-peer-reviewed assessments were added to have wide coverage. Clinical and pharmacy information included de-identified pharmacy dispensing files, patient self-report adherence and engagement measures, and national high-performing clinic datasets. The research consisted of non-financial firms listed at the KSE-100 Index and 30 most traded companies are chosen on the basis of market capitalization. And base year taken for KSE-100 index is 2015.

Patient engagement data consisted of records of bidirectional SMS messages, mobile app usage metrics like logins and alert acknowledgment, and social media activity (e.g., replies, likes, and retweets). Furthermore, a range of validated psychometric tools were utilized to measure mental health and usability of the system. These comprised the System Usability Scale (SUS), Beck Depression Inventory-II (BDI-II), Beck Scale for Suicide Ideation (BSS), Patient Health Questionnaire-9 (PHQ-9), Generalized Anxiety Disorder-7 (GAD-7), Montgomery-Åsberg Depression Rating Scale-Self rated (MADRS-S), and the Medication Adherence Rating Scale (MARS). Surveys also utilized constructs that were examined using Partial Least Squares Structural Equation Modeling (PLS-SEM), specifically in Fear of Missing Out (FoMO) and Problematic Internet Use (PIU) research.

3.1.2 Technology Stack

The MediSync platform was built by integrating contemporary, scalable, and platform-independent technologies to provide seamless operation in various pharmacy environments and end-user devices. The system's frontend utilized React.js for creating an interactive and modular pharmacy dashboard. React's virtual DOM and component reusability enabled it to be effective in handling dynamic data like real-time inventory updates and patient interaction histories. Aside from the web dashboard, it was also thought to use a cross-platform mobile interface through Flutter, where a single codebase could be deployed on both Android and iOS platforms, with optional support for patient-facing functionality. Core web technology such as HTML5, CSS3, and Bootstrap was used to ensure that the interfaces would remain responsive and visually comparable across screen sizes and devices.

For the backend, the system used Python as the main programming language, using either Django or Flask frameworks based on certain performance or deployment requirements. Django, with its native ORM, admin interface, and security features, was best suited for managing data-intensive operations such as user authentication and purchase logging. Celery was used as the asynchronous task manager, and Redis as the message broker to enable efficient scheduling and execution of background tasks. This configuration allowed the system to execute time-critical operations like generating and sending scheduled SMS reminders regarding impending medicine expiries without impacting the responsiveness of the system. To store and handle data securely, PostgreSQL was used as the relational database. It efficiently handled structured records such as patient data, purchase orders, and pharmacy stock. Firebase was also implemented to enable real-time inventory synchronization between pharmacies and the app. This provided real-time visibility of stock levels and dynamic promotional updates that patients could view through the app or SMS links, thus improving local pharmacy integration.

The SMS alert system constituted the communication backbone of MediSync. The Fast2SMS API was utilized to automate and send text messages to patients' mobile numbers. When patients bought medicine, they were sent a message with the name of the medicine, manufacturing date, expiry date, and purchase date. Additionally, Fast2SMS also sent timely expiry reminders a week prior to a medicine's expiry date, preventing the use of expired medicines and ensuring compliance.

3.2 Methodology

3.2.1 Literature Review

The first stage of the process of developing the system consisted of an overall evaluation of similar healthcare systems, with an investigation into current literature on SMS notification systems for healthcare, pharmacy integration models, and patient safety strategies. What was learned from the literature was used to determine the key features of the system. In particular, research on drug adherence and how notifications can facilitate patient compliance guided the development of the SMS notification logic, and prior research in pharmacy management systems assisted in sketching out local pharmacy integration details. The literature emphasized the requirement for trustworthy, real-time patient-pharmacy communication, which directed the inclusion of a specialized SMS Notification Engine in the system.

3.2.2 Experimental Studies Based on Field

Experimental design took a cue from field-based studies carried out by stakeholder interviews and visits to pharmacies. From these visits, there was gathered real-world feedback on the kinds of problems faced by pharmacists in tracing drugs, stock maintenance, and on-time communication to patients. Using the feedback derived from these visits, the system architecture was laid out to support both patients and pharmacy personnel. Real-time medicine purchase data entry, expiry date monitoring, and pharmacy inventory integration were seen as key features. The creation of modules like the Purchase Logging module, Expiry Scheduler, and Pharmacy Integration was directly driven by these field observations, making the system practical in a pharmacy setting.

Experimentation in field-based studies was crucial in grounding the system in actual pharmacy processes. Stakeholder interviews and visits to surrounding pharmacies uncovered critical issues in medicine tracking, expiry dates monitoring, and communication of patients. These findings directly impacted the development of central modules such as Purchase Logging, Expiry Scheduler, and Pharmacy Integration to ensure they catered to practical requirements. This ensured the system was technically sound, easy to use, and in harmony with pharmacy day-to-day processes.

3.2.3 Evaluation Metrics

The efficiency of the system was also tested with a thorough testing cycle, consisting of unit tests as well as integration tests to make sure that each module was working properly. Individual components of the system were tested using tools such as Postman, Selenium, and JUnit, while the reliability and accuracy of the SMS Notification Engine were specifically paid attention to. The realtime, accurate notification capabilities of the system were tested with test phone numbers, and data accuracy was validated with simulated transactions. User experience and responsiveness were also areas of evaluation metrics, with internal testing feedback utilized to refine the UI/UX design, notification timing, and integration of pharmacy promotions.

Metric	Used For	Scale/Description
SUS	App/system usability	Adjusted scores (e.g., from 81.5 to 76.9)
MARS	Mobile app usability & quality	Based on engagement, functionality
PHQ-9 / GAD-7 / MADRS-S	Mental health symptom change	Pre/post intervention measures
BDI-II / BSS	Depression and suicide risk	Used in pilot clinical studies
Engagement Logs	App usage, SMS reply rate	Behavioral adherence and engagement tracking
Adherence Rates	Pharmacy/self-report data	Percent of doses taken on time
Content Analysis	Social media/interviews	Thematic coding and response mapping
PLS-SEM	Model predictors	Statistical strength of predictor variables

The system was assessed using a variety of metrics to evaluate usability, effectiveness, and engagement. SUS and MARS quantified usability and quality of the app, while clinical measures such as PHQ-9, GAD-7, BDI-II, and BSS evaluated mental health outcomes in pilot research. Engagement logs and adherence rates monitored user activity and medication adherence. Content analysis of interview and social media responses gave qualitative feedback, and PLS-SEM confirmed the influence of main design features on user outcomes.

3.2.4 System Deployment and Accessibility

The system was deployed in a controlled setting with a subset of pharmacies and mock users to test its performance in realworld conditions. Pharmacy staff and patient feedback were gathered to determine the usability of the interface, the efficacy of the notifications, and the responsiveness of the system overall. This iterative rollout enabled ongoing enhancements in the Expiry Scheduler's scheduling accuracy and the Pharmacy Integration module's user interface. The feedback loop, directed towards realtime user interactions, was the key in tailoring the system's accessibility and configuring it to the requirements of both pharmacists and patients. The rollout also validated the scalability of the system and integrating with various pharmacy management systems so that the solution could be implemented in various environments.

The intervention was implemented through integrated hardware-app solutions with two devices: tactile and visual hardware alerts, and mobile reminders. GSM and RTC modules in IoT devices enabled SMS-based medication tracking and reminding. ESP modules and Firebase provided cloud connectivity for real-time logging and monitoring. Data security was maintained through encrypted storage and biometric authentication, with offline support for low-connectivity areas. Environments for deployment included pharmacy-based dashboards for on-the-spot observation of staff as well as patient homes equipped with mobile apps or

stand-alone devices. Usability in lower- and middle-income countries, as well as less digitally literate individuals, was thoroughly taken into account, especially in the context of mental health applications.

III. RESULTS AND DISCUSSION

4.1 Results of Descriptive Statics of Study Variables

Table 4.1: Descriptive Statics

Variable	Frequency / Percentage	Remarks
Smart medication products with alarms	75%	Common feature to aid reminders.
Products that send notifications	88%	Critical for real-time communication.
Features supported (general)	Multidose dispensing, locking mechanisms, portability	Enhances usability for various populations.
SMS-based systems effectiveness	High	Especially beneficial for high-risk patients due to scalability and reach.
Missed dose reasons	Forgetfulness, feeling better, medication unavailability	Highlights the need for two-way SMS and timely alerts.
mHealth app features	Personalized reminders, dose tracking, visual logs	Found to improve adherence and clinical outcomes.
High usability systems	Included offline alerts, visual cues, simplified UI	Engaged older/less tech-savvy users better.
Multi-user & caregiver access	Present in several systems	Promoted trust and usability.
Behaviorally informed features	Gamification, nudges, symptom tracking	Encouraged sustained engagement.
Pharmacy & clinic integration readiness	Essential for success	Influenced by staff workflows and support.
Emotional/behavioral support elements	Mood tracking, CBT-based nudges	Beneficial for users with mental health issues.
Cloud/mobile access	Present	Enabled scalability and secure data sharing.

This table provides an overview of major features and findings from current smart medication and mHealth systems that affect user engagement, compliance, and overall system performance. A high proportion (75–88%) of products had alarm and notification functions, which are critical for reminding patients and facilitating real-time communication. General functionalities such as multidose dispensing, locking, and portability enhance usability across various user groups. SMS-based systems were particularly effective for high-risk users because they were highly accessible. Typical reasons for missed doses forgetfulness or feeling better emphasize the importance of timely, two-way SMS reminders. Customizable app features such as dose tracking and visual logs have been demonstrated to enhance adherence and clinical outcomes. High-usability systems tended to incorporate offline capabilities and simplified interfaces, which were particularly useful for older or less technologically savvy users. Multi-cure and caregiver access capabilities promoted enhanced trust and usability, while behaviorally grounded tools such as gamification and symptom tracking promoted sustained usage. Successful systems also smoothly integrated with pharmacies and clinics, depending on workflow compatibility. Last, emotional well-being support features and secure cloud/mobile access added value by promoting mental health and facilitating scalable, flexible use.

Mobile health apps providing personalized reminders, dose reminders, visual medication calendars, and confirmation capabilities were found to enhance both adherence and clinical outcomes, such as improved blood pressure control.

Systems with high usability ratings and features optimized for older or tech-naïve users such as offline reminders, visual notifications, and reduced interfaces—experienced increased rates of engagement. Multi-user functionality, caregiver access, and biometric authentication also improved usability and trust and were therefore important to MediSync's target market. Beyond operation, the aesthetic of these systems was also considerably improved by understanding behavioral science fundamentals. Gamification, symptom management, and behavior nudges incentivized long-term use and self-management, whereas modular, HIPAA-compliant architectures facilitated expedient updates and data integrity. In implementation, effective integration of digital health systems was often reliant upon pharmacy readiness, clinic workflow readiness, and support from leadership.

Real-time adherence data were important to pharmacists and used for proactive intervention, consistent with MediSync's vision of shared patient and pharmacist interfaces. Clinical trials also evidenced that digital interventions, when aligned with user needs, mental health, and motivations, were found to be high in acceptability and engagement despite the absence of direct therapist participation. Emotional and behavioral support features, including mood monitoring or CBT-informed nudges, also increased compliance among users with comorbid mental health disorders. Cloud integration and mobile access also enabled scalable, secure data exchange, which was critical for remote monitoring and multi-platform synchronization. In conclusion, the study validates that an integration of intuitive design, automation, real-time monitoring, and individualized behavioral strategies leads to improved medication adherence and patient outcomes. MediSync's architecture, with its intelligent reminders, SMS integration, pharmacist dashboards, secure storage, and customizable notifications, is positioned to address these needs. Integrating lessons learned from

usability studies, behavioral science, pharmacy engagement, and scalable technologies, MediSync can efficiently solve adherence problems across various populations and healthcare environments.

IV.ACKNOWLEDGMENT

The authors are thankful to the academic assistance of the Department of Computer Science for facilitating technical direction and access to the appropriate literature that guided this work. They give special thanks to the pharmacists and health professionals who gave insights into present drug adherence issues. This work was also made possible by the Lab at Srinivas Institute of Technology that offered computational resources needed for the creation and testing of the MediSync system. Heartfelt thanks to the project guide and all contributors whose valuable suggestions and cooperation immensely improved the quality of this work.

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