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Enhancing Medication Adherence Through Behavioral Nudging: Potentials of a Smartphone App-Based Approach

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Abstract. Poor medication adherence remains a persistent challenge in healthcare, significantly impacting treatment outcomes and healthcare costs. While reminders and education have shown limited success, recent developments in behavioral economics suggest that subtle interventions, known as "nudges", can influence patient behavior more effectively. This paper presents the design, development, and initial evaluation of a smartphone application aimed at improving medication adherence through nudging techniques and interactive features. The app combines behavioral design principles with human-centered development to offer functions such as context-aware reminders, a social avatar interface (Adii), symptom and appointment tracking, and customizable scheduling. Nudging strategies include default settings, motivational prompts, social reinforcement, and salience through feedback mechanisms. The app's structure was co-designed with healthcare stakeholders, informed by literature and market analysis, and implemented using React Native for cross-platform compatibility. A two-phase usability study with 16 participants revealed that default schedules and visual feedback significantly influenced adherence behaviors. Personalized reminders and the avatar enhanced emotional engagement, while onboarding ease and offline support improved user trust. Though still in prototype phase, the app demonstrates promising utility for long-term adherence improvement. Future versions aim to incorporate adaptive nudging based on AI-driven user behavior modeling.

Keywords. Medication adherence, behavioral nudging, mobile health, user-centered design, digital health interventions.

1. Introduction

Medication non-adherence is a persistent and costly issue in global healthcare systems [1]. Studies indicate that up to 75% of patients with chronic conditions fail to follow prescribed regimens, leading to adverse health outcomes and increased medical costs [2]. Traditional interventions – such as education, regimen simplification, and direct reminders – often fall short, especially in long-term therapies. Key barriers include forgetfulness, low health literacy, lack of feedback, and limited motivation [3].

In recent years, behavioral science has introduced nudging as a promising alternative: subtle design changes that influence behavior without limiting choices [4]. In healthcare, nudges have improved attendance and vaccine uptake, but applications for

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daily medication adherence remain underexplored. Mobile health (mHealth) apps offer an ideal platform for such interventions [5], allowing nudges to be embedded in everyday user interactions. Importantly, apps can be tailored to personal routines and emotional needs, combining interface design with adaptive behavioral science.

This paper details the design and evaluation of a smartphone app that uses digital nudging and interactive elements to foster medication adherence. The project drew on literature, stakeholder workshops, and a usability-driven development process to create a tool that is accessible, emotionally engaging, and behaviorally effective.

2. Methods

2.1 Design Phase

The app was conceived through a structured human-centered design process [6]. A workshop with two healthcare entrepreneurs from the PraxaMed Center, guided by academic advisors, produced the initial concept and feature set. User stories were formalized into a requirements specification.

A targeted literature review (PubMed, Google Scholar) was conducted to identify effective nudging strategies for medication behavior, in which [7] and [8] proved to be central. Selected nudging types included default scheduling, salience cues, social reinforcement, planning prompts, and feedback mechanisms [8]. In parallel, a market analysis of 10 leading medication apps informed the interface logic and innovation space.

To prioritize features, a scoring matrix was developed evaluating feasibility, user effort, professionalism, and the risk of counterproductive incentives. The top-rated nudging strategies – reminders, planning prompts, and visual feedback [9] – were selected for development. The concept of a digital avatar (later named "Adii") emerged during early design rounds as a means of emotional engagement and para-social interaction.

2.2 Technical Implementation

The app was developed using React Native and Expo, enabling cross-platform deployment. Firebase was used for user authentication and backend services, including medication intake tracking, symptom entry, and appointment logging.

Key features included:

- Default medication scheduling (3 daily times: morning, noon, evening), adjustable by users
- Barcode-based medication entry, including Swiss eMediplan QR code parsing
- Adii, a customizable digital avatar for navigation and motivational feedback
- A personal calendar aggregating medications, symptoms, and appointments
- Offline functionality with local caching and encryption
- Accessibility features: large fonts, high-contrast themes, and voice guidance
- Structured onboarding tailored to user familiarity with digital tools

Reminders were managed through local push notifications, which could be customized by users in frequency and tone. All actions were logged in Firebase to support usage analytics.

2.3 Evaluation Phase

A two-stage usability study was conducted with 16 participants, recruited to reflect variation in age and digital literacy. Participants ranged in age from 23 to 76 (median: 51), with an average of 2.8 medications per person (range: 1–5). Due to time constraints, sessions were conducted remotely or semi-remotely.

Each participant completed:

- Session 1: Interaction with a clickable mockup for layout and logic validation
- Session 2: Full interaction with the functioning app prototype

Participants were asked to complete four core tasks:

- Add a medication using the barcode scanner
- Respond to a reminder and mark medication as taken
- Use Adii to log a symptom
- Navigate to their appointment calendar

Each task was rated by participants using a 5-point Likert scale on speed, clarity, usefulness, and design. Open-ended comments were collected in each session. Due to the implementation-oriented focus, only descriptive statistics were used in analysis.

3. Results

Quantitative feedback indicated that default medication schedules, automatically set to morning, noon, and evening times, were accepted without modification in 87% of cases. This acceptance rate suggests a strong alignment between pre-set scheduling and user expectations, affirming the effectiveness of default nudging strategies. Timely, context-aware reminders were rated helpful or very helpful by 75% of participants, especially when messages referenced relatable benefits like mobility or energy. Importantly, no users reported experiencing notification fatigue; all participants kept the reminder feature enabled throughout the study.

The emotional and social dimensions of the app were especially pronounced in relation to the avatar "Adii." Eleven of the sixteen participants described Adii's presence as positive, using terms like "engaging," "fun," or "soothing." Visual feedback tools, such as colored adherence bars and green checkmarks, were also well received, with several users noting that these features increased their sense of control and awareness over medication routines. App usage data revealed that participants who engaged regularly with symptom tracking, or appointment logging opened the app approximately twice as often per week (12 vs. 6 sessions), suggesting that these additional functionalities enhanced daily engagement and indirectly supported adherence.

Several qualitative patterns emerged during open-ended feedback. Older participants particularly appreciated the adaptive onboarding process, calling it "refreshing" and "less stressful" compared to other health applications. The ability to configure medication schedules in advance was highlighted by users who preferred "batch scheduling," often planning their entire medication routine on Sundays. In contrast, some participants used the app primarily to confirm that they had taken their medication, rather than to initiate the action, highlighting the app's potential as a habit stabilizer rather than as a behavior initiator.

Behavioral typologies began to surface based on usage patterns. Three distinct user types were identified: planners, who structured their routines in advance and valued scheduling features; spontaneous takers, who relied primarily on real-time nudges; and

confirmers, who used the app to verify or document actions already taken. This diversity underscores the need for flexible, personalized nudging strategies.

Finally, a subset of participants expressed interest in sharing their adherence scores with caregivers or physicians, indicating a potential future role for the app in collaborative care. Several users also suggested improvements to the avatar, such as increased expressiveness or customization options, further reinforcing the emotional and relational value of the app. Together, these results demonstrate how a combination of behavioral design principles, emotional interaction, and adaptive digital features can meaningfully influence medication engagement across diverse user groups.

Technically, the app performed reliably across all tested devices, with no major crashes and fast loading times. Barcode scanning proved efficient and reduced entry errors, especially helpful for users with limited familiarity with medication names. From a UX standpoint, the adaptive onboarding sequence was well received; users appreciated the ability to progress at their own pace. Older users in particular praised features like large fonts and voice guidance. Onboarding satisfaction also correlated with sustained engagement, underscoring the importance of early user experiences in mHealth adoption. Offline functionality emerged as a critical strength, especially in low-connectivity settings, where uninterrupted access to reminders and medication logs reinforced user trust and confidence in the app's reliability.

In the market analysis of existing medication adherence applications, Medisafe and Mediteo emerged as the most prominent competitors, each offering structured reminder systems, medication tracking, and integrations with external health services. However, neither integrates emotional or para-social elements such as avatar-based interaction. Our design aimed to fill this gap by focusing on user engagement through relational design, social reinforcement, and low-friction interaction, addressing motivational and emotional barriers often overlooked in more clinically oriented apps.

4. Discussion

The findings from the pilot implementation highlight how a behaviorally informed, user-centered smartphone application can support medication adherence beyond traditional reminder systems. Our app demonstrates the feasibility of combining behavioral nudges and para-social interaction in a mobile app for medication adherence. Compared to other nudging tools such as Medisafe and Mediteo, our app uniquely integrates a digital avatar for relational engagement, along with adaptive onboarding and non-intrusive feedback loops. The design explicitly avoids gamification but leverages emotionally positive reinforcement, defaults, and visual structure.

Initial results suggest that default scheduling, emotionally adaptive avatars, and personalized reminders can enhance adherence even without complex incentives. Behavior-type distinctions indicate opportunities for AI-supported personalization: planners might benefit from weekly nudges, while spontaneous users respond better to context-aware cues. The use of AI for adaptive nudging and behavior-based segmentation is a promising avenue for future work [10].

From a regulatory perspective, the current prototype does not provide therapeutic advice and is therefore not classified as a medical device under MDR (EU) or Swiss law. However, future versions with clinical decision support or medication recommendations would likely require MDR compliance and formal certification.

Limitations of this study include the small sample size, lack of a control group, and short test period. Nonetheless, the combination of behavioral insights, co-design, and

lightweight technical architecture provides a promising base for further clinical studies and real-world deployment.

Importantly, our early design decisions were informed not only by theoretical frameworks but also by competitive benchmarking. By identifying both functional overlaps and experiential gaps between our prototype and market leaders like Medisafe and Mediteo, we were able to tailor our intervention toward emotional engagement and relational reinforcement. This approach complements the strong existing focus on functionality in the adherence app market and opens a new dimension for improving long-term medication behavior through empathy-driven digital design.

In particular, the differentiated user behaviors observed in the evaluation – ranging from planners to confirmers – highlight the importance of tailoring not only content but also interaction style and rhythm. Nudging is most effective when aligned with a user's decision-making context, suggesting that future developments should incorporate behavioral profiling during onboarding and dynamically adjust interface elements and notification strategies. The relational component, embodied in the avatar, may further serve as a vector for trust and accountability in self-care routines, especially for users facing social isolation or motivation loss in chronic disease management. Such personalization and emotional alignment may prove decisive for real-world uptake and long-term effectiveness of adherence technologies.

In conclusion, the prototype demonstrates that simple behavioral nudges, combined with practical features and a friendly digital avatar, can effectively support medication adherence. The app is easy to use, emotionally engaging, and adaptable to different user types. With further testing and refinement, it offers a promising, scalable solution for improving long-term adherence in everyday healthcare settings.

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