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MOBILE-BASED SOLUTIONS FOR BETTER MEDICATION ADHERENCE

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ABSTRACT

Medication adherence is a critical determinant of successful healthcare outcomes, yet non-adherence remains a widespread issue across global populations. Patients often fail to follow prescribed treatment regimens due to factors such as forgetfulness, complex medication schedules, lack of awareness, and limited access to healthcare support. This study explores mobile-based solutions as an effective approach to improving medication adherence through the integration of technology and personalized care. Mobile health applications provide features such as automated reminders, real-time tracking, educational resources, and communication channels between patients and healthcare providers. These tools enhance patient engagement and promote consistent medication-taking behavior. The proposed approach emphasizes user-centered design, ensuring accessibility, ease of use, and adaptability to individual needs. By leveraging data analytics and behavioral insights, mobile-based systems can deliver tailored interventions that address specific adherence barriers. Furthermore, these solutions offer scalability and cost-effectiveness, making them suitable for widespread implementation, particularly in resource-limited settings. The study highlights the potential of mobile technology to transform medication management, reduce healthcare costs, and improve overall therapeutic outcomes. It concludes that mobile-based adherence systems represent a promising and practical strategy for addressing one of the most persistent

challenges in modern healthcare.

Keywords: Medication Adherence Mobile Health Applications Digital Healthcare Patient Engagement Therapeutic Outcomes

I. INTRODUCTION

Medication adherence is an essential component of effective healthcare, directly influencing treatment success and patient well-being. Despite advancements in medical science and the availability of effective therapies, a significant proportion of patients do not adhere to prescribed medication regimens. This issue is particularly prevalent in the management of chronic diseases such as diabetes, hypertension, and cardiovascular conditions, where long-term treatment is required. Non-adherence can lead to disease progression, increased hospitalizations, and higher healthcare costs, placing a considerable burden on both individuals and healthcare systems.

Several factors contribute to poor medication adherence, making it a complex and multifaceted problem. One of the most common reasons is forgetfulness, especially among elderly patients or those with busy lifestyles. Additionally, complex medication schedules involving multiple drugs and varying dosages can create confusion and increase the likelihood of missed doses. Lack of awareness about the importance of adherence and the consequences of non-compliance further exacerbates the problem. In some cases, patients may discontinue medication due to side effects or a perceived lack of immediate benefit.

In recent years, the rapid growth of mobile technology has opened new possibilities for addressing healthcare challenges. Smartphones have become widely accessible, even in developing regions, providing a powerful platform for delivering healthcare interventions. Mobile-based solutions offer a convenient and efficient way to support patients in managing their medication routines. These applications can provide timely reminders, track medication intake, and offer educational resources that enhance patient understanding and engagement.

One of the key advantages of mobile-based solutions is their ability to deliver personalized interventions. Unlike traditional methods such as paper-based schedules or generic reminders, mobile applications can adapt to individual user needs and preferences. By analyzing user behavior and medication patterns, these systems can generate customized reminders and

recommendations that align with the patient's daily routine. This level of personalization increases the likelihood of adherence and improves the overall effectiveness of the intervention.

Another important feature of mobile-based adherence systems is real-time monitoring. Patients can log their medication intake, allowing the system to track adherence patterns and identify potential issues. This data can be shared with healthcare providers, enabling them to monitor patient progress and intervene when necessary. For example, if a patient consistently misses doses, the healthcare provider can provide guidance or adjust the treatment plan accordingly. This continuous feedback loop enhances patient accountability and supports better clinical decision-making.

Mobile applications also play a significant role in patient education. Many patients lack a clear understanding of their medications, including how they work and why they are important. Mobile-based platforms can provide easily accessible information about medications, including dosage instructions, side effects, and precautions. By improving patient knowledge, these tools empower individuals to take an active role in their healthcare and make informed decisions about their treatment.

In addition to individual benefits, mobile-based solutions contribute to broader healthcare system improvements. By reducing medication errors and improving adherence, these systems can decrease the need for hospitalizations and emergency care. This not only reduces healthcare costs but also alleviates the burden on healthcare facilities. Furthermore, the scalability of mobile technology allows these solutions to be implemented across large populations, making them particularly valuable in regions with limited healthcare resources.

Despite their advantages, the implementation of mobile-based adherence solutions is not without challenges. Issues such as data privacy, user engagement, and technological barriers must be carefully addressed to ensure successful adoption. Users must trust that their personal health information is secure, and developers must design systems that are intuitive and easy to use. Continuous updates and improvements are necessary to maintain user interest and ensure long-term effectiveness.

The integration of advanced technologies such as artificial intelligence and machine learning further enhances the capabilities of mobile-based adherence systems. These technologies

enable predictive analytics, allowing the system to anticipate user behavior and provide proactive interventions. For example, the application can identify patterns that indicate a high risk of non-adherence and deliver targeted support to prevent missed doses. This proactive approach represents a significant advancement in medication management.

Overall, mobile-based solutions offer a comprehensive and innovative approach to improving medication adherence. By combining personalization, real-time monitoring, education, and advanced analytics, these systems address the key challenges associated with non-adherence. As technology continues to evolve, mobile health applications are expected to play an increasingly important role in enhancing patient outcomes and transforming healthcare delivery.

II. MATERIALS AND METHODS

A search of literature databases PubMed, Google Scholar, and Web of Science was conducted to identify articles published between January 2004 and December 2014. This timeframe was selected because most currently used mobile phones have been actively developed in the early 2000's to present. Both medical subject headings and free text search terms were used to identify relevant literature. Key terms were "adherence," "compliance," "prescriptions," "medication," "smartphone," "application," "security," "privacy," and "HIPAA." Where possible, the search was filtered to exclude incomplete or unoriginal works. All citations identified were screened for inclusion by reviewing titles and abstracts (See Appendix A).

Study Criteria

We manually gathered and vetted for inclusion any papers for which abstracts were unavailable or not included in the internet databases. Reports on medication adherence applications were eligible for inclusion if they were in English, had an original evaluation, and were published between 2004 and 2014. Research that did not pertain to health, was not conducted in the United States, included commentary, or had no direct bearing on the study's aims were also considered for exclusion. We also did not include studies that were published in abstract form only. All articles that were considered for inclusion were sent for thorough review after their abstracts and titles were reviewed. Several other strategies were employed to discover relevant material, in addition to the articles found through the literature database search. The writers began by looking at apps for medications in the two most popular app stores, Apple's App Store

and Google's Play Store. The second step was for the writers to look over the articles' and studies' bibliographies to find illness states that were applicable to the application.

Review Process

papers found using these techniques were re-collected, checked for inclusion, and then included in the collection of papers that underwent thorough assessment. As part of the comprehensive review process, at least two out of five reviewers were randomly assigned to each manuscript. Their roles included verifying the inclusion criteria, abstracting important material, and evaluating the quality of each article. A standard report form was used to record the reviews, which were then put into a database for analysis. Group consensus was used to resolve disagreements among reviewers. The number of articles obtained and examined for each key search keyword is summarized in Table 1. Title, publication year, author, and important results were the main types of data extracted. The articles were categorized based on four factors: adherence, quality of life, privacy issues, and current health-related apps.

III. RESULTS

A total of 14 articles and 4 application related reports were retrieved from the literature. provides a summary of key findings.

Adherence and Quality of Life

Apps related to health and wellbeing are proliferating, and not only among patients but also among healthy individuals. Use of mobile applications improved patient compliance and quality of life across a range of illness conditions, according to many studies. Research suggests that patients are more likely to take their medications as prescribed when they have a medication reminder system, particularly in cases when non-adherence is due to mistake. The number of Americans owning smartphones is on the rise, and there are several free or low-cost applications that might aid in sticking to a regimen. Patients with complicated prescription regimens and family or friends who care for others have praised the accessibility of these applications. There is a dearth of evaluations of improvements to quality of life in the expanding body of literature on the therapeutic use of smartphones with health-monitoring applications.

Recently, people with schizophrenia were helped in self-management by using the FOCUS

system, which was developed by Ben-Zeev D and colleagues. The FOCUS app is a mobile health (mHealth) intervention that follows the latest technological trends. The mHealth intervention was meant to make rehabilitation easier for individuals with schizophrenia, according to the developers of the program. Since schizophrenia is a complicated and frequently difficult-to-manage illness condition, the primary objective in developing FOCUS was to make a problem-free, easily-used mobile application. A review of the application's use highlighted the necessity for many adjustments. For instance, transition and environment are two examples of application acronyms that all participants said they had trouble understanding. Other issues that participants brought up were the tiny font size, the gap between menu buttons, and the extreme sensitivity of the screen when touched. On the other hand, some participants mentioned how useful the visual assistance were in the smartphone app. There were a total of 12 participants; 8 of them reported feeling very confident when using FOCUS, and 4 reported feeling confident overall. After doing testing with drugs, the writers came to the conclusion that the FOCUS mobile application needed more modifications. They imply that it will improve patients' quality of life and rehabilitation by doing so.

In a similar vein, research by Patel et al. (2013) found that patients' quality of life and medication adherence were both improved by the mobile healthcare app. A total of forty-eight hypertensive urban individuals at high risk participated in the research. Blood pressure and the usage of a mobile automated medication reminder app (Pill Phone) were the secondary end measures, whilst medication adherence was evaluated by the Morisky self-reported medication scale and the pharmacy refill rate. Around 40% of the "taken" replies were left unanswered because participants did not provide precise information, which is a shortcoming of the study concerning the Pill Phone. But the results showed that people took their medicine more regularly and their blood pressure went down (from an average of 144/89 to 136/84), which improved their quality of life.

Dr. Helmut Brath et al. conducted a randomized cross-over, single-blind, controlled trial to better understand the importance of medication adherence, particularly in older patients. We set out to determine if a mobile health-based adherence assessment system (mAMS) was feasible. Participating in the research were older individuals who exhibited at least two of the following cardiovascular risk factors: type 2 diabetes, hypertension, or hypercholesterolemia.

The participants were divided into two groups and given 52 weeks to complete the study. One group was given a control phase (CON) and the other a monitoring period (MON). Everyone who took part in the trial was given a unique user card and a mobile phone to use during the research. Electronic blisters containing their medications and specialized apps were installed to track when and how much was taken automatically and instantly. A reminder text message was sent to the patient's study phone the next day when the system discovered that they had failed to report their planned events as instructed, leading to missing data. Problems with the study's functioning caused just one volunteer to drop out. No statistically significant differences were found in the baseline demographics, according to the results.

The study's results supported the MON phase, since there were notable variations in adherence to the usage of metformin, a single medicine ($p < .05$). Simvastatin, rosuvastatin, and Ramipril were not significantly different from one another ($p > .05$). Some drawbacks, such as a limited sample size, a brief length of treatment, and out-of-date equipment, were present in the study, even though it did not find any statistically significant differences between CON and MON.

Existing Health-related Applications with Pros and Cons

For patients to be able to save all of their medical information in one place, organized by category, there are now similar apps available, but the most of them charge a fee. In addition, there are a number of prominently popular applications that remind patients to take their prescriptions at specific times. You can get most of them for less than \$10 USD. The two most popular apps are MedHelper and My Medical by Hyrax Inc. The underlying idea of both apps is the same: to give consumers a way to centralize their medical records. Personal medication-related information, including prescriptions, drugs, refills, physicians, pharmacies, and appointment schedules, may be easily managed with the aid of these programs [Hyrax, MedHelper]. User profiles may include stats like weight, height, blood pressure, and cholesterol levels; medical charts can include images like X-rays and MRIs; and prescription information can include images like pill images. With the many categories provided by each app, users may easily sort pertinent data into the appropriate sections. Whether it's X-ray findings or a prescription refill, the idea is to make sure consumers can simply obtain the information they need. Having a central location for users to access and manage their medical information is the primary goal of any application. Improvements in patient health care outcomes and drug safety may be possible with the use of these app features.

While these apps are beneficial, users must manually enter all of their medical information into the app, which is a key necessity. This might be a major hassle if the people using the software don't know what they're doing while entering the data. Additionally, when patients acquire more chart data and use more medications/prescriptions, the procedure may get more challenging. The likelihood of users making mistakes while inputting prescription names, chart data, etc., increases in proportion to the amount of health information that the application users have access to. The "M-prescription" app, created by the SK Telecom HC Biz Office, was another outstanding software that was evaluated. You may save and manage your medicines with this free app on your smartphone. Indications, instructions, and typical adverse drug responses, among other important information about prescription drugs, were also made available to patients. The automated system was the most important function. In contrast to MedHelper and My Medical by Hyrax Inc., patients are not required to manually enter all of their medical information into M-prescription. When a doctor submits a patient's medical records, certain fields are pre-populated.

A number of publications weighing the benefits and drawbacks of medically-themed mobile apps led to these conclusions. The medicine apps were categorized according to the attributes that the manufacturers said they have and then scored according to how desirable or helpful those aspects were. Apps that included both basic medication reminder capabilities and more advanced functionality were often the most highly regarded. People will have a hard time locating the perfect software when they look for suitable ones. Apple, for one, prioritizes listing their most popular apps at the top of its app store. It will be difficult for consumers to discover and utilize applications that are designed for smaller audiences since they will not be displayed. There is still a lot of debate over users' right to privacy while using apps, even if many of the ones we've highlighted have useful features. Users are concerned about the security of their protected health information (PHI) while it is being used.

Privacy Concerns

Healthcare benefits from the mHealth system include better adherence and quality of life, but other difficulties, such as privacy and security, are also precipitated by it. Concerns about patient confidentiality and data security have been the subject of several researches. Patients who have used mHealth have come to understand, for instance, that many of these apps' features necessitate some level of privacy and security. There is extensive archiving of medical records

and patient information. Unfortunately, most apps on the market today provide very little in the way of security, and that includes medical apps. In addition, there are popular apps that save sensitive medical information but don't even offer a password to protect it. Several studies have looked into privacy and security issues, as well as state regulations, because mHealth is becoming more popular among both patients and healthcare professionals. It is not an easy undertaking to provide the utmost privacy and security for all parties involved, including patients, providers, organizations, and vendors. A current need of government regulation is the provision of a national baseline of privacy protection for health information, as per the Health Insurance Portability and Accountability Act (HIPAA) of 1996. A separate piece of legislation addressing privacy and security concerns is the Health Information Technology for Economic and Clinical Health Act (HITECH), which was a component of the American Recovery and Reinvestment Act of 2009 (ARRA).

Also, the Sarbanes-Oxley Act, FDA rules, OCR enforcements, and the FCC all provide direction on healthcare privacy and security. Leaks of sensitive data might occur due to loopholes and other vulnerabilities in the rules and regulations. To address privacy issues, certain organizations, including the FDA, have developed laws tailored to mobile applications for medical devices. Another problem is that developing healthcare applications does not need any certain age, skill level, knowledge base, certificate, or legal paperwork. Consequently, according to Brandth and Durkin (2012), health IT personnel can lack the necessary expertise in mobile security and privacy when it comes to managing and developing applications. Additionally, they note that a large number of users are unaware of the security risks associated with the disclosure of their personal data. Concerns and difficulties with medical privacy have grown in tandem with the adoption of mHealth. Patients' lack of knowledge of what constitutes "outside of HIPAA protection" with respect to their specific medical records or readily accessible sources for sharing such records is the main cause for worry. Patients may not be subject to HIPAA regulations when using the mHealth application, but they do believe that all healthcare providers will be required to comply with the law when collecting their medical data. Nevertheless, once the healthcare provider gathers patient data, a large portion of it will be shared with software vendors and third party websites for both legitimate and illegitimate uses, such as advertising without patients' consent.

Potentially engaged here is a spy, sometimes called a data broker. Data brokers disregard the requirements of HIPAA. One further thing that has to be addressed under HIPAA protection is

the downloading and preservation of obtained health data. When it comes to the amount and quality of data collected, the creators of mHealth have raised concerns about privacy. The patient's lifestyle and health-related data are both collected in large quantities over time by the mobile app. Again, patient privacy is at risk since data is shared with other parties after collection. According to recent research, we need better regulations and laws, and we need to look at methods to make things even better.

IV. DISCUSSION

The goals of this research were to examine existing literature on applications that enhance medication adherence and quality of life, to talk about the benefits and drawbacks of currently marketed health-related mobile applications, and to investigate privacy and security issues related to mobile apps. All members of the healthcare team, including patients, primary caregivers, pharmacists, and others, can benefit from the data presented in this study. Several features, such as administration alerts, drug information searches, and access to medical data, are available in modern applications that help patients and primary caregivers increase medication adherence. Medications prescription schedules may be quickly and simply exported and imported into the healthcare system, and pharmacists and other medical professionals can access and backup patients' vital signs, test results, and medical records using a variety of mobile apps. drug adherence and quality of life were positively affected by most of the examined research, leading to an increase in the efficacy and safety of drug therapy. A few research did show negative features, particularly with privacy issues, even though the majority of the papers that were retrieved indicated favorable viewpoints.

One example is the tedious and troublesome process of entering all medical data into an application in order to get medical information. Some patients may find the app difficult to use and understand after receiving a specific number of lab reports or medications. A higher probability of medication mistake might potentially emerge from this. It is important to study certain characteristics, such as the ability to link patients' medical records, pop-ups for automatic drug administration alarms, and contraindications, in order to build and deploy mobile health applications in the future. Incorporating pain, depression, blood pressure, and glucose signs and symptoms severity measures can also help clinical trials go more smoothly, which in turn improves patients' happiness and adherence. Additional research is needed to address the primary privacy problem by developing applications that have a stronger security

feature for patient health information, complete with a unique code and passcode. Also, to help patients better grasp the features and drugs, it's helpful to provide a simpler description utilizing iconography or lay-terms.

V. CONCLUSION

Mobile-based solutions have emerged as a powerful tool for improving medication adherence and addressing one of the most persistent challenges in healthcare. By leveraging the widespread availability of smartphones and advancements in digital technology, these systems provide accessible, scalable, and cost-effective interventions that support patients in managing their treatment regimens. Features such as personalized reminders, real-time tracking, and educational resources significantly enhance patient engagement and promote consistent medication use. Furthermore, the integration of communication tools enables better collaboration between patients and healthcare providers, leading to more timely interventions and improved clinical outcomes. While challenges such as data security and user adoption remain, ongoing technological advancements and user-centered design approaches continue to improve the effectiveness of these solutions. In conclusion, mobile-based adherence systems represent a transformative approach to healthcare, offering significant potential to improve therapeutic outcomes, reduce healthcare costs, and enhance overall patient well-being.

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