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Mobile Applications for Medication Adherence Among Diabetes Patients: A Narrative Review of Current Evidence and Future Directions

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Abstract; *Mobile applications (apps) have proven to be helpful tools which enable the support of diabetes patient medication adherence by providing functions for reminders tracking and educational materials. The investigation focuses on evaluating current research regarding mobile app effectiveness towards boosting medication adherence among diabetes patients. A review evaluation of research papers demonstrates the potential advantages which include superior treatment results and enhanced patient participation and blood glucose regulation abilities. The analysis includes descriptions of the application usability difficulties that patients experience alongside their preference patterns and healthcare system integration issues. The review investigates the effectiveness of individualized intervention strategies as well as the influence of real-time feedback together with provider communication that both exist within mobile apps. Clinical trials must advance and app characteristics should standardize to guarantee their positive impact on adherence across all patient types. The field requires research to build specific and easy-to-use mobile applications and artificial intelligence integration and systematic investigation of data security measures for achieving patient consent. The analysis shows encouraging value of mobile applications which enhance diabetes medication adherence yet acknowledges there must be ongoing development using evidence-based practices within this expanding mobile health sector.*

Keywords*: diabetes, medication adherence, mhealth, mobile apps*

INTRODUCTION

Diabetes exists as a global healthcare emergency that affects millions of patients all over the world through heavy demands on healthcare resources. People with diabetes must practice effective condition control since it helps avoid complications that include cardiovascular disease and neuropathy and kidney failure (Mudaliar, 2004). The proper execution of medication use through adherence stands as the fundamental part of diabetes management because it aids patients to take their treatments as prescribed. Research shows that numerous diabetes patients fail to properly follow their drug protocols which results in unfavorable disease outcomes (Glowińska, 2008). The expanding mobile technology space

brings increasing interest in developing mobile applications which support patients in medication adherence. The developed applications consist of different features that assist patients in medication monitoring and provide reminder notifications while offering educational content. Mobile health (mHealth) applications designed for smartphones demonstrate promising potential to transform diabetes patient management of their medical treatments because smartphones appear increasingly widespread each year (Teruel, 2010; Kjos, 2019).

Diabetes forms a lifelong metabolic problem that makes blood sugar rise too high because of insufficient insulin or poor insulin function (Sripath, 2020). People with diabetes need to stay on treatment through medicines plus health changes plus normal blood testing for their whole life. To achieve good diabetes control patients need to properly follow their prescription medicines both oral drugs and insulin. Inadequate medicine use causes poor blood sugar monitoring which raises the odds of developing major diabetic health complications including heart problems and nerve damage (Jimenez, 2020; Sheehy, 2014). Healthcare systems and patients end up paying more while facing increased emergency trips and hospital visits due to patients not following their treatment plan. Research shows that many diabetes patients fail to stick to their prescribed medicines correctly while doctors know how important proper medication use is for patient health (Huang, 2019). Unsuccessful treatment results from patients forgetting to take their medicines as prescribed plus not knowing their medicine plan and finding it hard to follow complicated medication schedules. The persistent issue of patients not following their treatment plans negatively affects diabetes care and proves hard to overcome despite all efforts to help patients (Han, 2014; Georgieva, 2023).

This review will study how mobile applications help people with diabetes take their medications properly. Since patients now use digital health tools frequently we need to test how effective mobile apps really are at helping individuals stick to their medication plan. This research examines all published data to show how well these applications help patients follow their medications and change their treatment behavior. Specifically, our study will analyze if mobile health applications make diabetes patients take their medications better. Our assessment depends on studying clinical research and other proof to find out if mobile apps help diabetes patients take medicine better while controlling their blood sugar and running their disease better.

METHOD

Methodology for Literature Selection

Stage	Number of Articles
Initial Search	821
Review Articles	097
Articles Related to Mobile Health Apps	187
Articles Excluded for Relevance	402
Articles Included in Narrative Review	135
Breakdown of Included Studies	50 clinical trials, 35 observational studies, 50 reviews

This research project selected studies about mobile apps for diabetes patients to use their medicines on time using a strict method. This research properly selected and evaluated studies to pick the best high-quality materials for analysis.

Databases Used

The author ran a complete search through several scientific database systems to collect all existing research data. The databases used included: Scopus (471 articles), PubMed (165 articles), IEEE Xplore (17 articles), and Cochrane (168 articles).

Keywords Used

Our keyword combination helped us detect the right studies for our analysis. Our search criteria aimed to find publications about mobile application use and its impact on people with diabetes medication adherence. For the research we utilized these specific search terms: ("mobile application" OR "mobile app" OR "smartphone application" OR "digital health") AND ("medication adherence" OR "compliance" OR "medication management" OR "treatment adherence"). Search combination of terms including "diabetes", "diabetes mellitus" and other forms. (monitor OR intervention OR control OR management).

Screening Process

Our selection process used defined screens to pick high-quality research for the review. The team performed screening according to PRISMA framework requirements. The research team applied this procedure to evaluate candidate papers.

Duplicate Removal:

Baseline finding screening eliminated 192 studies because they appeared in multiple database sources.

Title and Abstract Screening:

Our team eliminated 379 articles that did not match our research focus about mobile apps for diabetic medication following the removal of duplicate entries.

RESULT AND DISCUSSION

MOBILE APPS FOR MEDICATION ADHERENCE: KEY FEATURES

Reminder and Notification Systems

Most mobile apps that support medication adherence include reminder and notification tools. These systems fight the primary obstacle of remembering by sending patients details about their medicine schedule at proper moments (Jimenez, 2020). Mobile apps help users remember their medication times by sending push notifications SMS messages and alarm alerts. Users can select their preferred times for the app to send alerts about medication intake. The computer system helps users remember and take all their medicines at scheduled times which is especially useful when handling multiple prescriptions (Mitra, 2023; Ghozali, 2024). Several research studies confirm how reminder systems help people take their medications correctly. Many research studies prove that both personalized and standard reminder systems help people with diabetes take their medications more reliably. The study printed in Diabetes Technology & Therapeutics proves that patients using mobile app medication reminders take their drugs better than patients who do not use this tool. The research shows that regular reminders help people maintain their right behaviors by taking their medicine as directed which results in healthier management of diabetes (Duan, 2016).

Tracking and Monitoring Functions

Medication adherence apps let their users monitor their medicine use through tracking features that show real-time medical status (Babaskin, 2022).

Reporting Tools for Adherence Summaries

These apps include tools that make adherence records available to patients and their healthcare providers. These programs build complete records about medicines taken and health indicators along with their long-term development. The reports give patients ways to see how well they take medication and improve their routine while doctors view these data to guide them with medication changes and identify treatment problems. The technology allows medical teams and patients to view their medical information together so both sides can make decisions based on current facts (Murugan, 2024).

Educational and Behavioral Support

Many diabetes management apps help patients learn more about their condition plus offer support to motivate them toward proper treatment follow-up (Chong, 2025).

Gamification Techniques

Several mobile apps use gamification elements to keep patients interested and support their continuous medication use. The system provides virtual prizes if patients follow their medicine schedule and reach their wellness targets regularly. The system helps patients monitor their achievements and development steps helping them feel successful while staying committed to their treatment. Using game elements in treatment helps patients want to follow their diabetes management plan better while making the experience less demanding (Maher, 2022; Wright, 2022).

Cognitive-Behavioral Interventions

Using cognitive-behavioral therapy methods inside mobile applications helps improve patients' medication following abilities. The software offers step-by-step CBT treatment to help patients overcome behavior and belief challenges that affect their medication following. These treatments work to modify patient thinking and mental frameworks that lead patients to forget their medicine or become overwhelmed by their disease. Apps provide assistance when they help people find solutions to why they cannot take medications properly (Kim, 2025).

Personalization and Customization

Mobile medication apps now help patients with diabetes by offering options that match their unique health needs. Tailored designs make patients liker the app more because they can use it in ways that match their daily habits and medical schedule (Corsica, 2024).

Customizable Medication Schedules

The system lets users adjust their medication plans to match what their patients need specifically. The applications let users enter all their medicine information to develop a personal notification system about when and how much to take. The feature helps patients take their medications as scheduled because the system matches their specific treatment schedule. Customized medicine schedules help a patient stick to their treatment plan better because they eliminate issues caused by changes in daily routines (Das, 2023; Durga, 2024).

AI-Driven Features for Adaptive Recommendations

Advanced medical tools now present AI methods that fine-tune their reminder systems based on how a patient sticks to their treatment. AI monitors patients' medication tracking details plus health markers and past reminder outcomes to optimize their feedback and change suggestions. When patients have uneven adherence to their treatment the app changes reminder schedules and presents extra support methods to aid better medicine taking. The AI elements in the app help it respond automatically but also take steps ahead to support patients achieve better medication adherence outcomes (Sujitha, 2024).

Effectiveness of Mobile Apps in Medication Adherence

Study	Focus Area	Study Design	Key Findings	Notes
[31]	Efficacy of mobile device apps in supporting medication adherence	Systematic review of randomized controlled trials with meta-analysis	Mobile device apps demonstrated efficacy in supporting medication adherence	The meta-analysis indicated that patients using mobile apps were more likely to self-report adherence to medications (OR 2.120, 95% CI 1.635 to 2.747)
[32]	Mobile apps for medication management	Review and analysis	Certain mobile applications effectively support adherence to taking medications	The study highlighted the need for consistent evaluation of app effectiveness in supporting medication adherence
[33]	Impact of mHealth chronic disease management on treatment adherence and patient outcomes	Systematic review	mHealth interventions showed mixed results in improving adherence to medication; feasibility and acceptance by patients were noted	The study emphasized the potential of mHealth interventions but called for more rigorous evaluations to determine effectiveness
[34]	mHealth: An updated systematic review focusing on HIV/AIDS and tuberculosis long-term management using mobile phones	Systematic review	Mobile phone technology, combined with web-based interfaces, increased convenience and efficiency in data management compared to paper-based systems	The review suggested that mHealth interventions could enhance data management and patient monitoring in chronic disease management

[35]	Use of e-Compliance, an innovative biometric system for monitoring tuberculosis treatment in rural Uganda	Direct observation study	Intervention patients had a higher cure rate (55% vs. 28.3%) and a lower default rate (0% vs. 7%) compared to control groups	The study demonstrated the potential of biometric systems in improving treatment outcomes in resource-limited settings

Effectiveness of Interactive and Adaptive Features

Studies show that interactive apps which adapt their functionality to users have greater success in making patients better follow their medication plans. Apps that let users access personal medicine schedules and track their health using AI feedback will keep users more motivated in taking their medications (Santo, 2019; Wang, 2024). These capabilities build a better user experience by changing the app to fit the patient's development and requirements throughout time. Apps that track adherence patterns and send customized motivation help patients deal with specific Adherence issues caused by forgetfulness and lack of motivation. Systems that respond to users' needs create better treatment results compared to standard alerts because they handle multiple aspects that impact how patients follow instructions.

Impact on Clinical Outcomes

Various research studies evaluated mobile application effects on clinical outcomes including glycemic control and HbA1c reduction however this research produced inconsistent findings. Research studies show different levels of effect on clinical outcomes such as blood glucose control when using these medication-enhancing mobile applications.

Mixed Evidence on HbA1c Reduction

Mobile applications bring positive effects on blood sugar control according to evidence demonstrating decreased HbA1c results in several research studies. The applications foster diabetes control by assisting patients to improve medication compliance and stimulate increased frequency of glucose monitoring. Patients who use tracking functions together with medication reminders maintain better blood sugar stability that leads to lower diabetes complications risks. Scientific investigations have observed improved HbA1c levels which advances total disease control (Hao, 2018). Different research studies produced conflicting results regarding HbA1c changes when medication adherence improved. Mobile application effectiveness at improving medication adherence does not reflect positively on patient clinical results showing better outcomes. The ability of mobile apps to decrease blood glucose level metrics (HbA1c) depends on additional disease influences such as lifestyle behaviours and meal plans and exercise routines alongside patients' general disease development status. Essential though adherence is in diabetes management it does not function as the exclusive predictor of glycolic control as enhanced medication-taking behaviours often fail to produce decreased HbA1c levels (Yu, 2019).

Behavioural Changes and Patient Perception

The medication adherence mobile applications modify patient drug handling approaches and drive noticeable behavioural transformations while developing changes in patient perceptions of their health state and treatment process. These mobile applications have generated extensive research about their effects on patient mindsets and conduct.

Increased Self-Efficacy and Health Awareness

The use of medication adherence apps leads patients to develop stronger self-efficacy which is their confidence in handling both their diabetes condition and their required medication schedule [40]. Through their tracking systems and reminder features patients automatically gain strengthened health management skills that build their confidence to handle their condition. Users experience better health awareness since these apps display real-time data regarding their medication consumption and blood glucose values as well as other wellness measurements. Patient awareness growth stemming from these benefits leads individuals to adopt better health choices in their daily routines such as dietary alterations and exercise practice and medicinal compliance (Huang, 2019).

Challenges and Barriers in Mobile App Adoption

Digital Literacy and Technological Barriers

Technology adoption via mobile applications has dramatically changed how people interact with the world in daily activities particularly in communication and commerce. Several notable obstacles block the full utilization of advanced technology for older adults because many of them lack digital skills along with proper tech equipment. Older adults become the main group facing technological barriers because most of them do not understand contemporary technology (Liew, 2022). Users without adequate digital experience encounter difficulties using applications that operate with pre-established knowledge requirements which hinders their ability to capitalize from digital services. Moreover, individuals with low digital literacy—whether due to age, socioeconomic status, or educational background—also face significant hurdles. Users tend to avoid complex apps which demand high technical skills because these interfaces become unapproachable (Nautiyal, 2024). Basic account setup processes together with setting adjustments and security understanding cause problems for many users. The divide between digital information and users breaks down into social clusters which results in lasting inequalities by preventing some populace from accessing digital resources.

Sustained User Engagement

The main hurdle mobile apps face when they gain acceptance involves maintaining consistent user commitment across the time span. Users show strong preliminary interest in downloading mobile applications yet many abandon these programs shortly after installation especially when these apps are health-related or educational. Most users discontinue their app usage during the first weeks even if they displayed early dedication to the service. Users abandon mobile applications for multiple reasons which combine lack of motivation and decreased value and waning interest from the fresh perspective (Kidman, 2024). Long-term adherence research normally experiences high dropout rates because users need to interact with the app repeatedly for several months to multiple years. Normal usage brings its initial excited phase to an end which creates a decrease in regular contact with the application. Users in health and wellness sectors struggle to fulfill their long-term goals such as weight loss and fitness enhancement because continued commitment remains difficult to achieve (Al-Shamaileh, 2023).

Privacy and Security Concerns

Users refrain from adopting mobile applications and become unengaged because privacy and security challenges emerge as substantial obstacles when these applications advance into healthcare domains. The security risks become more significant because of the sensitive nature of stored personal information particularly in health-related apps. People particularly those in the patient category show avoidance of complete app usage because they have concerns regarding how their private information will be managed and dispersed. Users

avoid apps due to concerns about data protection together with app permission requirements and sharing of personal information with outside parties which triggers diminished trust and causes users to stop using apps. Security issues about data stand as one of the primary concerns. Health information bearing patients demonstrate heightened concern about data security risks together with stolen or improperly manipulated health data. Young people, as well as organizations, face extreme harm when this data is breached since this action results in personal damage and financial and reputational loss (Ouazzani, 2020).

Regulatory Challenges in Ensuring Compliance with Healthcare Privacy Laws

The Health Insurance Portability and Accountability Act (HIPAA) functions as the primary regulatory standard to defend sensitive patient data throughout United States healthcare operations. Mobile health apps lack explicit coverage from HIPAA regulations thus creating an exposed zone for security and privacy protection. An absence of specific guidelines regarding non-HIPAA-compliant mobile health applications creates difficulties for patients in verifying their health data protection. Application privacy depends heavily on such security requirements as HIPAA standards and local equivalents to protect patient data (Gregory, 2021).

Recommendations for Future Development

Standardized Evaluation Metrics

Standardized assessment criteria for mobile health applications (mHealth) need to be developed because this sector continues expanding in healthcare. Because numerous health-oriented apps exist in the market for various medical conditions and uses it becomes essential to create established metrics for reliable performance evaluation. Standard evaluation metrics for the future need to fulfill the following requirements: The critical element for mHealth app success depends on user engagement levels and adherence rates (Wang, 2024). Different applications lack a standard technique for measuring adherence in their systems. A standardized adherence metric system allows consistent monitoring of user engagement which can include tracking app usage frequency together with task completion rate as well as tracking consistency in health-related data such as medication adherence and physical activity and symptom reporting. The metrics employed need to assess immediate engagement while ensuring continuous long-term application usage so users can obtain sustained benefits from the app.

Development of Validated Frameworks for Assessing App Effectiveness

The effectiveness assessment of mHealth apps must include validated frameworks which measure their effectiveness through proven scientific evidence. The purpose of these frameworks will direct developers to build applications which derive from evidence-based medical practices and deliver risk-free health solutions. Application success frameworks should contain evaluation categories which measure both medical results and behavioral adjustments along with end-user contentment and the rate of health condition enhancement from year to year. The same level of clinical trials and validation processes which medical drugs and devices need to pass must be applied to mobile health apps for assessing their effectiveness (Moshi, 2018). A comprehensive app evaluation system needs trial procedures which measure health results in standardized laboratory settings to check an application's influence on particular medical conditions. Data-driven monitoring of possible risks and adverse events resulting from app usage would be performed while validating the app works without harming users.

Personalization and AI-Driven Interventions

Such technologies have the ability to change healthcare provider delivery methods especially when treating chronic diseases while monitoring wellness and behavioral health. AI-

driven interventions combined with personalized approaches offer several crucial recommendations to improve mHealth app effectiveness according to the following points.

AI-Based Adaptive Interventions to Tailor Adherence Strategies to Individual Patients

Personalized health interventions with unique needs and preferences as well as individual behaviors form the basis of delivery through AI-based systems into customized health plans through apps. The process of data analysis through AI algorithms produces custom treatment plans that are designed specifically for individual patients. These systems evaluate patient data points that include health status together with activity levels and behavioral history and environmental conditions. Patient-specific recommendations and diet plans and exercise regimens with motivational features are adjustable by patient-built data on their progress and personal taste. A diabetes application tracks blood sugar readings to modify its insulin dosage reminder system which delivers precise and important treatment directions (Khanna, 2024).

Integration with Healthcare Ecosystems

Letting mobile health applications (mHealth) prosper depends on their integration with healthcare delivery systems that exist currently. Integration that works effectively between systems advances both communication processes and patient care delivery and delivers improved health results. For successful implementation health providers must actively participate in adherence programs while Electronic Health Record (EHR) systems must achieve interoperability capability. The biggest challenge for mHealth exists because mobile health apps do not efficiently exchange information with Electronic Health Record systems (Ojeda-Carreño, 2017). The healthcare ecosystem relies on EHRs to store comprehensive patient records together with diagnoses and treatments along with medications for treatment protocols. Mobile health apps that do not link with EHR systems create data fragmentation which produces insufficient health data for medical providers to have complete patient profiles. The synchronization of mobile app data pertaining to activity tracking and medication adherence and symptoms monitoring with electronic health records happens automatically through better interoperability between applications and EHR systems thus providing healthcare providers with accurate real-time patient information (Were, 2021).

Addressing Digital Divide

Universal healthcare remains inaccessible because of the digital divide which exists between those who possess modern technology access and those who lack it entirely. The digital divide exhibits special intensity within communities which count low income among their members combined with rural locations and limited access to internet and smartphones and digital skills. The successful implementation of digital health solutions for everyone needs the creation of basic low-technology solutions which will draw the technological divide closer. The following strategies should be applied to overcome digital divide problems within mobile health applications: The accessibility design of simple low-tech applications remains essential because numerous underprivileged population members can’t access top smartphones or constant internet access. Image simplicity and user-friendly design need to become primary development priorities for application creators. The combination of small size and steady power efficiency with user-friendly design gives these individuals a new way to participate online. Mobile applications designed with text-based features along with accessible navigation structures and simple graphic elements will provide service to numerous users. The simplification process of these apps makes it possible for users with both minimal tech experience and basic phone models to engage effectively (Shera, 2021; Magdalene, 2015).

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CONFLICT OF INTEREST

The author declares no conflict of interest.

CONCLUSION

Medical applications serve as effective tools which help diabetic patients develop better medication adherence. The apps enhance treatment management through drug reminder systems in addition to progress monitoring tools and educational modules and individualized treatments which increase patient success in their therapeutic plans. Studies show mobile health (mHealth) technology helps improve patient medication following by decreasing health risks and producing better health results. A broad implementation of effective mobile health apps requires solutions for multiple essential barriers. Digital literacy stands as a significant challenge because different patients exhibit varying capability to use mobile technology. Older patients along with people with minimal background in digital tools face difficulties using intricate app designs which prevents them from receiving benefits from these solutions.

REFERENCES

[1] Mudaliar S. Intense Management of Diabetes Mellitus: Role of Glucose Control and Antiplatelet Agents. *J Clin Pharmacol* 2004; 44: 414–422.

[2] Glowińska I, Małyszko J. Powikłania sercowo-naczyniowe u chorych z nefropatia cukrzycowa. *Przeglad Kardiodiabetologinczny* 2008; 3: 217–222.

[3] Górriz Teruel JL, Beltrán Catalán S. Cambios inducidos por la enfermedad renal crónica en los pacientes con diabetes. *Avances en Diabetologia* 2010; 26: 235–241.

[4] Kjos AL, Vaughan AG, Bhargava A. Impact of a mobile app on medication adherence and adherence-related beliefs in patients with type 2 diabetes. *Journal of the American Pharmacists Association* 2019; 59: S44-S51.e3.

[5] Sripath N, Taneepanichskul N, Taneepanichskul S. Mobile application development process for diabetes patients in primary care unit, Bangkok, Thailand: A case study of EASYDM mobile application. *Systematic Reviews in Pharmacy* 2020; 11: 1100–1107.

[6] Jimenez G, Lum E, Huang Z, et al. Reminders for medication adherence in Type 2 diabetes management apps. *Journal of Pharmacy Practice and Research* 2020; 50: 78–81.

[7] Sheehy S, Cohen G, Owen KR. Self-management of diabetes in children and young adults using technology and smartphone applications. *Curr Diabetes Rev* 2014; 10: 298–301.

[8] Huang Z, Tan E, Lum E, et al. A smartphone app to improve medication adherence in patients with type 2 diabetes in Asia: Feasibility randomized controlled trial. *JMIR Mhealth Uhealth*; 7. Epub ahead of print 2019. DOI: 10.2196/14914.

[9] Han W, Mulgund P, Sharman R, et al. Self health management mobile application for diabetic patients and the impact on treatment adherence. In: *35th International Conference on Information Systems 'Building a Better World Through Information Systems', ICIS 2014*. 2014.

[10] Georgieva N, Tenev V, Kamusheva M, et al. Diabetes Mellitus—Digital Solutions to Improve Medication Adherence: Scoping Review. *Diabetology* 2023; 4: 465–480.

[11] Nopitasari A, Thesa Ghozali M. Exploration of Self-Management Strategies for Type 2 Diabetes Mellitus among patients in Rural Community Health Centers: A Descriptive Study. *Res J Pharm Technol* 2024; 5974–5980.

[12] Mitra S, Punde S, Dhote H, et al. Healthcare App on Medical Adherence. *International Conference on Emerging Trends in Engineering and Technology, ICETET*; 2023-April. Epub ahead of print 2023. DOI: 10.1109/ICETET-SIP58143.2023.10151629.
[13] Ghozali MT. Innovations in Asthma Care: Efficacy of Mobile App-Assisted Patient Education in Promoting Asthma Self-Management. *The Palgrave Encyclopedia of Disability* 2024; 1–15.
[14] Chanane N, Mirza F, Naeem MA. Co-Designing a Medication Notification Application with Multi-Channel Reminders. *ACIS 2020 Proceedings - 31st Australasian Conference on Information Systems*.
[15] Fenerty SD, West C, Davis SA, et al. The effect of reminder systems on patients' adherence to treatment. *Patient Prefer Adherence* 2012; 6: 127–135.
[16] Duan XX, Wang YL, Zhang GF. Design of medication regularly reminding device. *Information Science and Electronic Engineering - Proceedings of the 3rd International Conference of Electronic Engineering and Information Science, ICEEIS 2016* 2017; 449–452.
[17] Babaskin DV, Litvinova TM, Babaskina LI, et al. Popular Diabetes Mobile Applications for Medication Intake Monitoring. *Res J Pharm Technol* 2022; 15: 347–356.
[18] Murugan K, Reddy SG, Reddy S, et al. Smart IoT Medication Companion. *2024 3rd International Conference on Smart Technologies and Systems for Next Generation Computing, ICSTSN 2024*. Epub ahead of print 2024. DOI: 10.1109/ICSTSN61422.2024.10671211.
[19] Mitra S, Punde S, Dhote H, et al. Healthcare App on Medical Adherence. *International Conference on Emerging Trends in Engineering and Technology, ICETET*; 2023-April. Epub ahead of print 2023. DOI: 10.1109/ICETET-SIP58143.2023.10151629.
[20] Ghozali MT, Satibi S, Forthwengel G. The impact of mobile health applications on the outcomes of patients with chronic kidney disease: a systematic review and meta-analysis. *J Med Life* 2023; 16: 1299.
[21] Chong CJ, Makmor-Bakry M, Hatah E, et al. A qualitative study of type 2 diabetes mellitus outpatients' perspectives on readiness, acceptance and barriers of mobile apps for medication adherence. *Patient Educ Couns*; 131. Epub ahead of print 2025. DOI: 10.1016/j.pec.2024.108547.
[22] Maher CA, Olds T, Vandelanotte C, et al. Gamification in a Physical Activity App: What Gamification Features Are Being Used, by Whom, and Does It Make a Difference? *Games Health J* 2022; 11: 193–199.
[23] Ehrler F, Gschwind L, Hagberg H, et al. A Medication Management App (Smart-Meds) for Patients After an Acute Coronary Syndrome: Pilot Pre-Post Mixed Methods Study. *JMIR Pediatr Parent*; 9. Epub ahead of print 2025. DOI: 10.2196/50693.
[24] Kim SK, Park SY, Hwang HR, et al. Effectiveness of Mobile Health Intervention in Medication Adherence: a Systematic Review and Meta-Analysis. *J Med Syst* 2025; 49: 13.
[25] Wright JH, Chan SR, Mishkind MC. Practical considerations for emerging types of telebehavioral health care: Computer-assisted cognitive behavior therapy and mobile applications. *Virtual Mental Health Care for Rural and Underserved Settings* 2022; 145–164.
[26] Corsica JA, Kelly MC, Bradley LE, et al. Mobile apps for diabetes self-management: An updated review of app features and effectiveness. *J Behav Med*. Epub ahead of print 2024. DOI: 10.1007/S10865-024-00525-Y.
[27] Corsica JA, Kelly MC, Bradley LE, et al. Mobile apps for diabetes self-management: An updated review of app features and effectiveness. *J Behav Med*. Epub ahead of print 2024. DOI: 10.1007/S10865-024-00525-Y.
[28] Das SK, Maheshwari RA, Chakraborty J, et al. Enhancing drug related problem (DRP) management in Indian healthcare through AI integration: An insight view. *Intelligent Pharmacy* 2023; 1: 175–178.
[29] Durga KP. AI Clinical Decision Support System (AI-CDSS) for cardiovascular diseases. *Using Traditional Design Methods to Enhance AI-Driven Decision Making* 2024; 64–76.

[30] Sujitha S, Fathima SM, Kavya S. Prototyping a Smart Medication Management System with Machine Learning-based Dosage Recommendations. *Proceedings of the 5th International Conference on Smart Electronics and Communication, ICOSEC 2024* 2024; 1402–1406.
[31] Armitage LC, Kassavou A, Sutton S. Do mobile device apps designed to support medication adherence demonstrate efficacy? A systematic review of randomised controlled trials, with meta-analysis. *BMJ Open*; 10. Epub ahead of print 30 January 2020. DOI: 10.1136/BMJOPEN-2019-032045.
[32] Tabi K, Randhawa AS, Choi F, et al. Mobile Apps for Medication Management: Review and Analysis. *JMIR Mhealth Uhealth*; 7. Epub ahead of print 2019. DOI: 10.2196/13608.
[33] Hamine S, Gerth-Guyette E, Faulx D, et al. Impact of mHealth chronic disease management on treatment adherence and patient outcomes: a systematic review. *J Med Internet Res*; 17. Epub ahead of print 1 February 2015. DOI: 10.2196/JMIR.3951.
[34] Devi BR, Syed-Abdul S, Kumar A, et al. mHealth: An updated systematic review with a focus on HIV/AIDS and tuberculosis long term management using mobile phones. *Comput Methods Programs Biomed* 2015; 122: 257–265.
[35] Snidal SJ, Barnard G, Atuhairwe E, et al. Use of eCompliance, an innovative biometric system for monitoring of tuberculosis treatment in rural Uganda. *Am J Trop Med Hyg* 2015; 92: 1271–1279.
[36] Santo K, Singleton A, Rogers K, et al. Medication reminder applications to improve adherence in coronary heart disease: A randomised clinical trial. *Heart* 2019; 105: 323–329.
[37] Wang T, Huang YM, Chan HY. Exploration of Features of Mobile Applications for Medication Adherence in Asia: Narrative Review. *J Med Internet Res*; 26. Epub ahead of print 2024. DOI: 10.2196/60787.
[38] Hao Y, Xu H. A Prospective Cohort Study on the Management of Young Patients with Newly Diagnosed Type 2 Diabetes Using Mobile Medical Applications. *Diabetes Therapy* 2018; 9: 2099–2106.
[39] Yu Y, Yan Q, Li H, et al. Effects of mobile phone application combined with or without self-monitoring of blood glucose on glycemic control in patients with diabetes: A randomized controlled trial. *J Diabetes Investig* 2019; 10: 1365–1371.
[40] Amer FAM, Mohamed MS, Elbur AI, et al. Influence of self-efficacy management on adherence to self-care activities and treatment outcome among diabetes mellitus type 2 sudanese patients. *Pharm Pract (Granada)*; 16. Epub ahead of print 1 October 2018. DOI: 10.18549/PHARMPRACT.2018.04.1274.
[41] Huang Z, Lum E, Jimenez G, et al. Medication management support in diabetes: A systematic assessment of diabetes self-management apps. *BMC Med*; 17. Epub ahead of print 17 July 2019. DOI: 10.1186/S12916-019-1362-1.
[42] Liew EJY, Teh PL, Ewe SY, et al. Understanding Challenges as Needs: Smartphone Usage Among Malaysian Older Women in Rural Areas. *IEEE International Conference on Industrial Engineering and Engineering Management* 2022; 2022-December: 1201–1205.
[43] Nautiyal S, Shrivastava A, Deka C. Smartphone Adoption and Healthcare Usage Among Older Adults in India. *Act Adapt Aging*. Epub ahead of print 2024. DOI: 10.1080/01924788.2024.2440246.
[44] Kidman PG, Curtis RG, Watson A, et al. When and Why Adults Abandon Lifestyle Behavior and Mental Health Mobile Apps: Scoping Review. *J Med Internet Res*; 26. Epub ahead of print 2024. DOI: 10.2196/56897.
[45] Al-Shamaileh O, Sutcliffe A. Why people choose Apps: An evaluation of the ecology and user experience of mobile applications. *International Journal of Human Computer Studies*; 170. Epub ahead of print 1 February 2023. DOI: 10.1016/J.IJHCS.2022.102965.
[46] Ghozali MT, Murani CT. Relationship between knowledge and medication adherence among patients with tuberculosis: a cross-sectional survey. *Bali Medical Journal* 2023; 12: 158–163.

[47] Ouazzani Z El, Bakkali H El, Sadki S. Privacy preserving in digital health: Main issues, technologies, and solutions. *Social, Legal, and Ethical Implications of IoT, Cloud, and Edge Computing Technologies* 2020; 253–276.
[48] Gregory M, Roberts C. Maturing an Information Technology Privacy Program: Assessment, Improvement, and Change Leadership. *Research Anthology on Privatizing and Securing Data* 2021; 2008–2022.
[49] Wang T, Huang YM, Chan HY. Exploration of Features of Mobile Applications for Medication Adherence in Asia: Narrative Review. *J Med Internet Res*; 26. Epub ahead of print 2024. DOI: 10.2196/60787.
[50] Ghozali MT. *Buku Ajar Sistem Informasi Manajemen untuk Farmasi*. 1st ed. Yogyakarta: Deepublish, 2024.
[51] Moshi MR, Tooher R, Merlin T. Suitability of current evaluation frameworks for use in the health technology assessment of mobile medical applications: A systematic review. *Int J Technol Assess Health Care* 2018; 34: 464–475.
[52] Trezza A, Visibelli A, Roncaglia B, et al. Unsupervised Learning in Precision Medicine: Unlocking Personalized Healthcare through AI. *Applied Sciences (Switzerland)*; 14. Epub ahead of print 1 October 2024. DOI: 10.3390/APP14209305.
[53] Khanna A, Jain S. Personalized Drug Treatment: Transforming Healthcare with AI. *Artificial Intelligence and Machine Learning in Drug Design and Development* 2024; 295–319.
[54] Ojeda-Carreño D, Cosío-León MA, Nieto-Hipólito JI. Relevant tools for tackling interoperability problems on heterogeneous electronic health record systems: An exploratory research. *Revista Mexicana de Ingenieria Biomedica* 2017; 38: 25–37.
[55] Were MC, Savai S, Mokaya B, et al. mUzima Mobile Electronic Health Record (EHR) System: Development and Implementation at Scale. *J Med Internet Res*; 23. Epub ahead of print 1 December 2021. DOI: 10.2196/26381.
[56] Shera A, Iqbal MW, Shahzad SK, et al. Blind and visually impaired user interface to solve accessibility problems. *Intelligent Automation and Soft Computing* 2021; 30: 285–301.
[57] Magdalene J, Rajkumar N, Vinod V. Accessibility of mobile phone for visually impaired person with low vision. *International Journal of Applied Engineering Research* 2015; 10: 254–257.