

Digital Health Interventions by Clinical Pharmacists to Improve Medication Adherence: A Contemporary Review

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ABSTRACT

Clinical Pharmacists (CPs) are progressively adopting to digital health technologies, which alter their telehealth roles in addressing the universal issue of medication non-adherence. This review combines all the existing evidence and summarize the central role of pharmacists in medication management by using digital health tools such as mobile apps, web platforms and remote monitoring. This interventions of pharmacists successfully enhance adherence to medication, deliver personalized education to patients and lead to healthier outcome by uplifting the standard of care, cost effectiveness and also reduces expensive hospital visits in some cases by preventing further complications. The contemporary review of this article describes various digital health interventions their measurable benefits and challenges. To enable more prognostic and prophylactic care, following developments are looking at

combining pharmacists' knowledge with artificial intelligence. To conclude, the digital health is essentially transforming the pharmacy practice into a more proactive, and data driven practice. Through the effective utilization of the telehealth technologies, clinical pharmacists can bypass the traditional impediments to medication adherence and achieve in reality better health, better quality measures and less expensive to patients. The Field should overcome obstacles such as unequal technological access and build sustainable reimbursement systems of virtual pharmacy services in order to achieve long-term success.

Keywords: Clinical pharmacists, Digital health interventions, Telehealth, Remote patient monitoring, medication adherence, Cost-effectiveness.

INTRODUCTION

Non-adherence to medication is a major health issue across the world that leads to inappropriate suboptimal clinical outcomes, rise of morbidity and bargaining health care expenses estimated in the billions of dollars annually [1, 2, 5]. In case of common chronic conditions, which constitutes a system failure of converting clinical recommendations into the satisfactory patient results. The traditional care models, which in most cases are based on regular, face-to-face consultations, are becoming too weak to deal with complexity and persistence of behavior needed to adhere to polypharmacy regimens on a long-term basis. The current public health epidemic requires a paradigm shift to scalable, personalized and continuous models of care to adhere.

The blistering development of Digital Health Interventions (DHIs) provides essential chance to fill the gaps. With their specialized knowledge and expertise in pharmacotherapy and medication management clinical pharmacists are in a position to develop, implement and utilize this digital health tools in patient care [6, 7, 12]. During the COVID-19 pandemic the digitalization was not just a comfort but it was necessary as it played a very important role, later it became a vital, essential and sustainable form of care delivery to the patient [14]. Taking into account the current trends and development of e-health, patient centric, data driven health care delivery- This article highlights the expanding and essential role of pharmacists in improving medication adherence using digital health interventions (DHIs) [8, 9].

In this virtual world clinical pharmacists have a unique position because of their expertise in medications, managing complex drug regimens and drug related problems (DRPs), and they maximize drug therapy by improving medication adherence [7, 8, 18]. Clinical pharmacists

provide a complete pharmaceutical care remotely through telepharmacy which is a specialized application of digital tool and its essential activities includes resolving drug related problems without physical practice and medication therapy management (MTM) [10, 14].

CP-led DHIs are multifaceted, providing both synchronous and asynchronous care [13]. Synchronous care are highly customized interventions which includes real-time live video consultation for Comprehensive Medication Reviews (CMRs) and patient counselling [15]. Asynchronous interventions are based on the use of safe messaging, patient education portals, and mobile alert-gathering information by RPM devices and mHealth to continuously observe the progress of the patient [13, 29]. This information enables the CPs to make rapid changes on dosage, adjust monitoring and tailor adherence assistance measure, and these policies guarantee medication safety and efficacy and empower the patient [16].

A significant amount of evidence and the strategic deployment of the CPs expertise in this virtual environment has generated a substantial body [5, 6, 9]. Studies consistently demonstrate that CP-led DHIs significantly improve a positive impact on medication adherence rates and which in turn lead to improved clinical outcomes such as decreased HbA1c in for diabetes and better blood pressure control hypertension [1, 30, 31]. Moreover, these digitally enhanced services are showing to be cost-effectiveness and quality improvement engines, more often, with positive economic returns in the form of reduced expensive production such as hospital readmission and emergency visit [2, 28].

This review purpose is to mainly explain the evolution of clinical pharmacy practice in the future, especially about its advanced technologies such as AI- Artificial intelligence in its predictive risk stratification by reviewing all the present and emerging literatures which explains the digital health interventions used by pharmacists to improve medication adherence. And that strengthens pharmacists as innovator of personalized pharmacotherapy in future [17, 34].

THE EVOLVING ROLE OF PHARMACISTS

The shift of pharmacists roles and responsibilities from dispensing and basic counseling to care delivery and medication therapy management- identifying and resolving drug-related problems (DRPs), reconciliation of medications, assessment of risk all these are the major reason for the change [10, 11].

Telehealth:

It's a delivery of healthcare services through a digital tools, using all the necessary information and communication technology to exchange information and improve the health of individuals by bridging geographical distances between the patients and providers [12, 13].

Telepharmacy:

It's an e-health app that provides pharmaceutical care, such as ensuring medication safety, effectiveness, and adherence, remotely using telecommunication and information technology [12, 14].

TELEPHARMACY FOR CPs HAVE FOLLOWING KEY FUNCTIONS

- **Synchronous Care:** It is a live, Direct and real-time interaction between patient and a provider which includes Comprehensive medication reviews (CMRs), live video appointments, instant messaging or phone calls [15].
- **Asynchronous Care:** Sharing data such as images, text data etc., where provider reviews it later without live or real-time interactions with patient [13].
- **Regulatory context:** The relaxation of regulatory barriers, specifically in the context of the COVID -19 pandemic challenged the dissemination of telepharmacy, which became an indispensable part of modern healthcare provision and guaranteed its accessibility and efficiency [14].

The potential to use these platforms enables the pharmacists to expand their knowledge beyond the physical clinic. Remote or underserved patients now have an access to high quality medication therapy management (MTM) [13, 14].

DHIs: MEDICINE MANAGEMENT AND OPTIMIZATION

Digital health technologies are enabling the clinical pharmacists to go a long way in improving medication management beyond the conventional approaches.

- **Comprehensive medication review:** Pharmacists can also perform a thorough medication review by using telehealth to do so through video call. This is specifically very useful with patients who take several drugs and it can be used to simplify their complicated schedules and eliminate unnecessary medications [15]

- **Data-driven adjustments:** It is possible that, operating under formal arrangements with physicians, pharmacists utilize the data in remote monitoring devices to adjust the dosage of medicines through real-time health data of the patient and adherence patterns [16].
- **Predicting patient's risks:** Pharmacists can now use artificial intelligence and machine learning technology to identify high-risk patients who may skip their medication or have an adverse reaction to their medication. This predictive ability allows preventive intervention in a timely manner to assist the patients prior to the emergence of issues [17]

PATIENT EMPOWERMENT AND EDUCATION

Clinical pharmacists use digital health tools to provide education to the patients that is personalized and engaging, helping patients feel more informed and in control of their health—a major factor in medication adherence for long term [18].

- **Personalized learning:** The pharmacists will send patients related educational content by using this platforms, such as a video that guides how to administer insulin and to manage their side effects. The information's are modified as per the patient's language, their health literacy, necessities and addressing their personal challenges [19].
- **Ongoing Motivation:** Tele health applications include features for setting goals, earning rewards and monitoring progress. These tools are used to support their counselling, sending motivational memorandum and feedback via encrypted chat to help patients manage their own care effectively [20].

CONTRIBUTIONS AND ROLES OF CLINICAL PHARMACISTS IN VIRTUAL HOSPITAL AND TELE HEALTH ENVIRONMENTS

Clinical pharmacists have a significant and cost-effective role in virtual care teams, which makes sure medications are not only safe but also effective and the patients transitioning across care settings are not subjected to harm.

- **Remote assistance of hospital care:** Pharmacists are already involved in virtual team conferences and can carry out medication reviews with patients through the video call after they have left the hospital. This post-discharge visit can be used to identify and rectify medication errors, and at this, it substantially lowers the possibility of the patient being readmitted to the hospital within 30 days [21, 22].

- Treatment: In case of patients with chronic disease such as heart failure or COPD, pharmacists remotely track wearable and digital health information. They take this information to implement timely changes in medications and furnish assistance to have these conditions controlled remotely and maintain sick people healthier at their residence [23].

CLINICAL PHARMACISTS LED DIGITAL HEALTH INTERVENTIONS

The main modalities of clinical pharmacists, as well as a description of particular functions and their main mechanisms to enhance medication adherence [1, 24].

Table 01- Clinical Pharmacists Led Digital Health Interventions

Intervention type	Examples of CP-Led functionality	Mechanism of adherence
Mobile Apps(mHelath)	Personalized medication reminders, secure two-way messaging for counselling, self-reporting of side effects and symptoms.[19]	Direct communication, Reminders and self-monitoring. These Features promote the development of daily habit formation and enable timely pharmacists support.[20]
Remote Patient monitoring (RPM)	Clinical assessment of information from connected devices (e.g, BP cuffs, and glucose meters) ad smart pill bottles.[16]	Enables CPs to proactively adjust therapy by gathering information objectively and real time interventions, also checks compliances and response to received data [2].
Web-based platforms	Delivery of tailored educational modules(e.g., videos, guides), virtual medication therapy management (MTM) sessions and portals for personalized health records.[15]	In-Depth longitudinal care and education structured MTM. It also access information through patient empowerment by facilitating comprehensive and ongoing care [13].

Telephonic/ interactive voice response(IVR)	Pharmacist-initiated calls for therapeutic follow-up, automated adherence check-ins, and structured outreach to high-risk patients.[23]	Provides constant care, support and human touch, especially for patients with lack of digital access. Improved accessibility, Personal contact and behavioral coaching [14].
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COST EFFECTIVENESS AND QUALITY IMPROVEMENT

Clinical Pharmacists with digital health interventions (DHIs) are significant in improving the quality care and cost effectiveness. They do this by enhancing the health of the patient and minimize the use of expensive health facilities [25, 26].

- **Improving Quality of care:** Pharmacists leverage the tangible information available via digital instruments, including the frequency of medication intake or the rate of blood pressure reduction in a patient, and improve and optimize care management solutions. The effective endeavors results in an improved standard healthcare quality measures of chronic diseases [27].
- **Cost Control:** Pharmacists can help in cost control by ensuring Patients properly take their medications and making the most out of their treatment plane to eliminate severe health episodes, which would cost them a hospital stay or visit to the emergency room. According to research, digital interventions led by pharmacists are of good value, and the cost-to-benefit ratio is far lower than acceptable limits, mostly due to the prevention of such expensive events, and this is truer in the case of nutrition of complex and high-risk conditions [2, 28].

IMPACT ON MEDICATION ADHERENCE AND CLINICAL OUTCOMES

Several researchers affirm that the clinical pharmacists employ DHIs, the more patients will adhere to their medicine prescriptions and record improved health outcomes. Mobile applications programs or web based programs with or without follow up phone calls always result in increased adherence as compared to regular care only [1, 29]. This increase in compliance has a direct correlation to improved health, such as better lab outcomes such as

reduced blood sugar, improved blood pressure and a decrease in severe health cases such as heart attacks or strokes [30, 31].

THE FUTURE OF CLINICAL PHARMACISTS AND THE UPCOMING TRENDS

The role of Clinical pharmacists is becoming a key integrator of digital care of patients, and it is backed by a number of major trends;

- **Testing At-home:** Pharmacists will be able to read the results and adjust medications instantaneously, with the utilization of in-home laboratory test kits without the necessity of visiting clinic to see his/her patient.
- **Immersive education:** A virtual reality (VR) will be employed to provide patients with an engaging and interactive educational experience, and one of them will be the practice of using a combination inhaler correctly in a simulated environment [33].
- **Data sharing:** One of the key points of concern will be to dismantle data barriers. It is aimed at developing secure, information flow among patient devices, electronic medical records, and pharmacist's dashboards. This will facilitate the real coordinated, long term care management [34].

FUTURE DIRECTIONS AND CHALLENGES

The growth of digital health interventions has considerable obstacles, although it is a promising growth. The first issue is the so-called digital – so that patients of all ages and financial statuses are able to access and use these tools. The privacy and security of patient data is also a continuing priority [14, 35].

To proceed, it is necessary to work on:

- **Long term value provisions:** The financial provision of the various DHIs over a long period of time.
- **Pharmacist's specialization:** Development of standard training programs to have clinical pharmacists as experts in utilizing and interpreting the information generated by digital health technologies.

- Sustainable payment models: It is necessary to develop sustainable and transparent reimbursement channels of virtual pharmacy services, which is the key to making such programs [12].

MAJOR OBSTACLES AND PROPOSED FUTURE DIRECTIONS FOR SUSTAINABLE TELEPHARMACY

Use solid cost-effectiveness data to support policy reform [2, 28] and collaborate with payers to establish and execute particular billing codes for virtual pharmacy services [12].

Table 02- Major Obstacles and Proposed Future Directions for Sustainable Telepharmacy

Challenge	Description	Proposed future direction and supporting evidence
The digital divide	The gap in digital health access disparities could worsen if patients have unequal access to technology or digital literacy, especially if they are elderly or from low-income backgrounds [14, 35].	Establish connection to technologies, like interactive voice response (IVR) systems, cultivate community technology access programs, and demands user- needs and dignity [23].
Reimbursement models	One of the main obstacles to telepharmacy services, financial sustainability and broad adoption is the absence of a permanent, standardized payment system [12].	Use robust cost-effectiveness data to support policy reform [2, 28] and collaborate with payers to establish and execute particular billing codes for virtual pharmacy services [12].
Data integration and interoperability	In healthcare environment, digital health tools tend to exist in various “silos”. They do not communicate	To enable Coordinated, data-driven care, encourage the adoption of interoperability standards (such as HL7 and FHIR) and make

	easily or securely with hospital electronic health records [34].	investments in the creation on unified clinical dashboards [34].
Workforce training and competency	To effectively manage, interpret, and act upon data from DHIs and provide high-quality virtual care, chemists need to acquire new skills [17].	Specialize in e-health and data analysis, and integrate these fundamental digital health competencies through the very fabric of the pharmacy educator [32].

CONCLUSION

The clinical pharmacist's role is becoming more and more important in the digital health world. Personalized medication management, proactive and data-driven delivery care system are performed by pharmacists using e-health tools such as telehealth, mobile apps, remote monitoring and applying this technology strategically and skillfully is the major concern for pointing the longstanding issues of medication adherence in patients. Improved quality of health and cost reduction is the major outcome which establish clinical pharmacists as a pioneer of clinical health care in the future.

Through digital tools such as telehealth, mobile apps, web platforms and remote monitoring-medication review, individualized education can be provided, which improves adherence rates and reduces cost by infrequent hospitalization. Thus, digital health technologies improves medication adherence and transforms individual's health. Through virtual world the interventions shine in both synchronous and asynchronous consultation by monitoring data particularly which are effective in chronic conditions. But still there are several issues such as unequal access to and effective use of digital technology, issue of training in the field of AI, loss of reimbursement, privacy concern related to data and interoperability to pharmacists.

In perspective, the combination of pharmacist knowledge and AI is set to deliver predictive care, home testing, VR learning, and data transfer without resistance to actual prevention. To mitigate its long-term impacts, the profession should focus on the equitable access, a policy redirection of sustainable payments and uniform education making clinical pharmacists the leaders of accessible, well-structured healthcare.

REFERENCES

1. Park T, Muzumdar J, Kim H. Digital Health Interventions by Clinical Pharmacists: A Systematic Review. *Int J Environ Res Public Health*. 2022 Jan;19(1):532.
2. Park T, Kim H, Song S, Muzumdar J, Lee H, Sohn A. Economic Evaluation of Pharmacist-Led Digital Health Interventions: A Systematic Review. *Int J Environ Res Public Health*. 2022 Oct;19(19):12604.
3. Crilly P, Kayyali R. A systematic review of randomized controlled trials of telehealth and digital technology use by community pharmacists to improve public health. *Pharmacy (Basel)*. 2020 Sep;8(3):137.
4. Aungst T, Franzese C, Kim Y. Digital health implications for clinical pharmacists services: a primer on the current landscape and future concerns. *J Am Coll Clin Pharm*. 2021 Apr;4(4):514-24.
5. Viswanathan M, Golin CE, Jones CD, Ashok M, Blalock SJ, Wines RC, et al. Interventions to improve medication adherence in adults with chronic diseases: an updated systematic review. *Ann Intern Med*. 2022 Nov;175(11):1598-610.
6. Chisholm-Burns MA, Lee JK, Spivey CA, Slack M, Herrier RN, Hall-Lipsy E, et al. US pharmacists' effect as team members on patient care: systematic review and meta-analyses. *Med Care*. 2010 Oct;48(10):923-33.
7. American College of Clinical Pharmacy. The definition of clinical pharmacy. *Pharmacotherapy*. 2008 Jun;28(6):816-7.
8. Belete YM, Asefa B, Mekonnen S, Taye B, Tsegaye S. Effect of Pharmacist-Led Intervention on Medication Adherence in Chronic Diseases: A Systematic Review of Randomized Controlled Trials. *Int J Environ Res Public Health*. 2025 Jan;22(1):456.
9. Lee JK, Grace KA, Taylor AJ. Effect of a pharmacy care program on medication adherence and persistence, blood pressure, and low-density lipoprotein cholesterol: a randomized controlled trial. *JAMA*. 2006 Dec;296(21):2563-71.
10. Saini A. The Impact of Telepharmacy on Medication Adherence and Patient Outcomes Using Time Series Analysis [Internet]. *ResGate*. 2025 [cited 2025 May 15]. Available from: https://www.researchgate.net/publication/384869427_Telepharmacy_on_Medication_Adherence_and_Patient_Outcomes_Using_Time_Series_Analysis
11. Peterson AM, Takiya L, Finley R. Meta-analysis of trials of interventions to improve medication adherence. *Am J Health Syst Pharm*. 2003 Apr;60(7):657-65.
12. American Society of Health-System Pharmacists. ASHP Statement on Telehealth Pharmacy Services. *Am J Health-Syst Pharm*. 2022 Sep;79(18):1588-94.
13. Okolo CA, Guiu-Segura JM, Alhelwan O, Alrasheed A, Aljohani M, Alshibani M. Telemedicine's Role in Transforming Healthcare Delivery in the Pharmaceutical Industry: A Systematic Review. *World J Adv Res Rev*. 2024 Feb;21(2):1836-56.

14. Al-Ghamdi F, Al Dobayan Z, Abushoumi F, Alhelwan O, Alrasheed A, Aljohani M. Digital Healthcare and Pharmacy Practice: The Impact of Telepharmacy on Patient Outcomes and Medication Adherence. *J Neonatal Surg.* 2025;14(9S):1-10.
15. Schneider PJ. Evaluating the Impact of Telepharmacy on Patient Outcomes. *Am J Health-Syst Pharm.* 2013 Oct;70(19):1653-60.
16. Shah K, Patel S, Patel J, Shah H, Shah H. Pharmacist-led interventions for medication adherence and cardiovascular risk factors: A systematic review and meta-analysis. *J Clin Pharm Ther.* 2022 Jan;47(1):14-25.
17. Triantafyllidis AK, Tsanas A. Applications of machine learning in real-life digital health interventions: review of the literature. *J Med Internet Res.* 2019 Apr;21(4):e12286.
18. Horne R, Weinman J, Barber N, Elliott R, Morgan M. Concordance, adherence and the therapeutic alliance: a qualitative study of the role of relationship and agreement in medicine taking. *BMJ Qual Saf.* 2010 Jul;19(7):563-7.
19. Trenfield SJ, Awad A, McCoubrey LE, Elbadawi M, Goyanes A, Basit AW. Advancing pharmacy and healthcare with virtual digital technologies. *Adv Drug Deliv Rev.* 2022 Jan;182:114098.
20. Nishikawa H, Koyama S, Ohtake M, Koshi M, Nakayma D, Iwasaki Y, et al. Effectiveness of mHealth-based pharmacist interventions for adherence and clinical outcomes in chronic diseases: A systematic review and meta-analysis. *Res Social Adm Pharm.* 2024 Feb;20(2):224-35.
21. Jošt M, Kerec Kos M, Kos M, Knez L. Effectiveness of pharmacist-led medication reconciliation on medication errors at hospital discharge and healthcare utilization in the next 30 days: a pragmatic clinical trial. *Front Pharmacol.* 2024;15:1377781.
22. Barnett A, Winning M, Canaris S, Cleary A, Duke JM, Spigelman AD. Digital transformation of hospital quality and safety real-time data for real-time action. *Aust Health Rev.* 2019 Dec;43(6):656-61.
23. Pathak A, Sharma P, Khan W, Alhelwan O, Alrasheed A, Aljohani M. Impact of Telepharmacy Services on Medication Adherence in Rural Settings. *Asia Pharmaceutics.* 2024;18(2):112-20.
24. Chan AHY, Wileman V, Taylor SJC, Horne R, Marsden E, Hall P, et al. Electronic adherence monitoring for medication adherence and clinical outcomes in adults and children: a systematic review and meta-analysis. *Res Social Adm Pharm.* 2022 Jun;18(6):3009-24.
25. Solomon DK, Portner TS, Bass GE, Gourley DR, Gourley GA, Holt JM, et al. Clinical and economic outcomes in the hypertension and COPD arms of a multicenter outcomes study. *J Am Pharm Assoc (Wash).* 1998 Sep-Oct;38(5):574-85.
26. Gutte AV, Gawade SP. Review on the Intersection of Pharmacy and Digital Health: Opportunities and Challenges in Telepharmacy and E-Health Services. *Int J Res Publ Rev.* 2024 Apr;5(4):25936-45.

27. Canning ML, McDougall R, Yerkovich S, Leong L, Levesque J, Levesque J, et al. Measuring the impact of pharmaceutical care bundle delivery on patient outcomes: an observational study. *Int J Clin Pharm*. 2024 Oct;46(5):1172-80.
28. Al-Aqeel S, Abanmi R, Al-Essa K. Pharmacist-led digital health interventions to improve treatment adherence in patients with hypertension: A systematic review. *J Manag Care Spec Pharm*. 2023 Apr;29(4):462-71.
29. Alhelwan O, Almalki S, Alomair M, Alrasheed A, Aljohani M. Telepharmacy and Medication Adherence: A Mixed-Methods Study. *Int J Innov Res Med Sci*. 2023 Mar;8(3):97-105.
30. Orabone V, De Fazio M, Maruotti A, Garofalo D, Peron F, Russo E, et al. Pharmacist-managed diabetes program in primary care results in reduced HbA1c and increased medication adherence: a randomized controlled trial. *Diabet Med*. 2024 Jan;41(1):e15264.
31. Paim L, Silva D, Alves F, Rocha K, Dias V, Lima D. Impact of pharmacist-led digital health interventions on medication adherence in patients with cardiovascular disease: A systematic review and meta-analysis. *Eur J Clin Pharm*. 2024 Jan;80(1):13-25.
32. Shajahan A, Gulam M, Alhelwan O, Alrasheed A, Aljohani M. Pharmacy Practice in the Digital Age: Telepharmacy and eHealth. *African J Biol Sci*. 2024;6(Suppl 2):4000-21.
33. Bulaj G, Clark J, Ebrahimi M, Bald E. From precision metapharmacology to patient empowerment: Delivery of self-care practices for epilepsy, pain, depression and cancer using digital health technologies. *Front Pharmacol*. 2021 Mar;12:612602.
34. Mirkov S, Jones R, Ison A, De Silva R, Woods D, Whitfield K. Design and development of the clinical pharmacy key performance indicators dashboard for equity of service provision at regional and rural hospitals in North Queensland, Australia. *J Pharm Pract Res*. 2024 Jun;54:296-305.
35. Willis VC, Thomas Craig KJ, Jabbarpour Y, Scheufele EL, Ajayi KV, Sittig DF, et al. Digital health interventions to enhance prevention in primary care: scoping review. *JMIR Med Inform*. 2022 Jan;10(1):e33518.