



## **Digital Technology for Improvement of Medication Adherence**

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### **ABSTRACT**

*Medication non-adherence is a major global health care challenge, especially with chronic conditions. It is a multi-factorial concept, that can be improved by a combination of several approaches including educational, behavioural, cognitive, and the use of adherence increasing aids. Patients, health care providers, and the health care system, together are involved in optimizing medication adherence. This chapter describes the various types of digital tools such as mobile phone applications, web-based education, engagement and gaming systems, smart pills, dispensers, packages and bio-ingestors, that are under various stages of development or available to address medication management with the goal of improving medication adherence. Most of these technological innovations provide holistic solutions to the patients in their complete health care journey, but a number of these digital adherence supporting tools still remain expensive and need compliance with regulatory standards and universal acceptance. Increased awareness amongst stakeholders, integration in health care system, and implementation of regulation policies for digital adherence tools can positively impact the patient's therapeutic outcomes.*

**KEY WORDS:** Digital, m- health, adherence, mobile health apps, non- adherence

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### **INTRODUCTION**

As per World Health Organization (2003), medication adherence is defined as "the degree to which the person's behaviour -taking medication, following a diet, and /or executing lifestyle changes corresponds with the agreed recommendations from a health care provider [33, 34]." On the other hand, compliance, a relatively older term, is defined as the extent to which a patient's behaviour matches with the prescriber's advice [6]. Compliance indicates how well a patient obeys the instructions related to medication given by the prescriber, whereas adherence signifies that the patient and prescriber integrate to improve the patient's health by considering the medical viewpoint of the prescriber and the lifestyle, values and preferences of the patient. Medication persistence is another related term, which is defined as the duration of time from initiation to discontinuation of therapy [10]. Medication adherence behaviour can be understood as a combination of two concepts: adherence; taking medications as prescribed and persistence; continuing to take the prescribed medication for the entire duration of the treatment. To study and understand the adherence of digital technology in the field of medical industry.

### **MATERIALS AND METHODS**

Medication adherence can be measured by a number of methods [1].

**1. Direct method:** including biochemical determination of detecting the presence of drug or its metabolite in the blood sample or the urine sample of the patient obtained by adding a nontoxic biological marker to the medication. This is a robust method, nevertheless it is not a practical method for routine use.

**2. Indirect methods:** including objective measurement of medication adherence through questionnaires filled by patients, self-reports, counting the number of pills, prescription refills records, electronic medication monitors, patient diaries, or using electronic medication event monitoring systems. Yet another indirect method includes subjective measurement of medication adherence obtained by enquiring the patients, their caregivers, and clinicians about the usage of medication.

Generally, a combination of the above mentioned methods is used for the assessment of medication adherence behaviour. Mathematically, adherence can be expressed as percentage of the actual medication

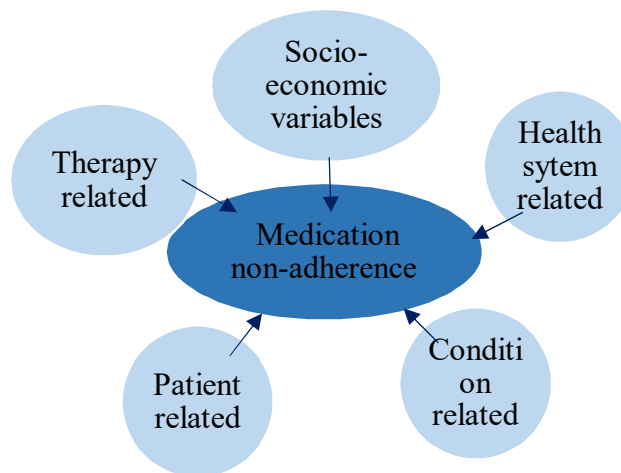
taken over a set period of time and can vary from 0% to over 100% [22]. Typically, medication adherence of 80% or more is required for optimal therapeutic efficacy. There are various ways to calculate medication adherence depending upon the method used. A simple formula to find it is given below:

$$\% \text{ medication adherence} = \frac{\text{number of doses taken}}{\text{number of doses prescribed}} \times 100$$

### NON-ADHERENCE TO MEDICATION

Patients may be adherent, partially or completely non adherent. Studies indicate that non-adherence accounts for nearly 50% of treatment failures and around 125,000 deaths and up to 25% of hospitalizations per year in the United States. It is estimated that adherence to chronic medications is around 50% [12]. Non-adherence poses a challenge at all levels of society for all types of diseases, irrespective of chronic or acute drug therapy or the type of drugs. Non-adherence results in wastage of medication and resources, poor health outcomes, decreased functional abilities, poor quality of life, increased hospital visits and stays and increased health care expenditure. Non-adherence is a major challenge for prescribers, healthcare systems, and other stakeholders because of its wide prevalence, consequent adverse outcomes and increased health care costs. Patients tend to miss doses, take medication intermittently or do not take them at all, without realizing that this can result in relapse, rehospitalisation, excessive dosage, enhanced resistance to antimicrobial drugs and adverse effect on the long-term outcomes. Non-adherence can also be viewed as unintentional and intentional. Non-adherence to medication is termed as intentional when the patient intentionally chooses to either stop or decrease the doses or number of prescribed medications due to personal beliefs about medication and treatment, lack of motivation and unusual expectations from the treatment. Unintentional non-adherence is attributed to patients' lack of cognition and capacity compromising their ability to adhere to the treatment regimen, or lack of access to health care and support [15].

The causes of non-adherence are multidimensional in nature ranging from patient's behaviour, type and severity of disease, complexity, number of medications, duration of the treatment, possible ADRs, social factors, economics involved in the treatment, relation and interaction between patient and provider, follow ups and/or organizational factors linked with the health care system. Figure 1 shows the multidimensional determinants of non-adherence.

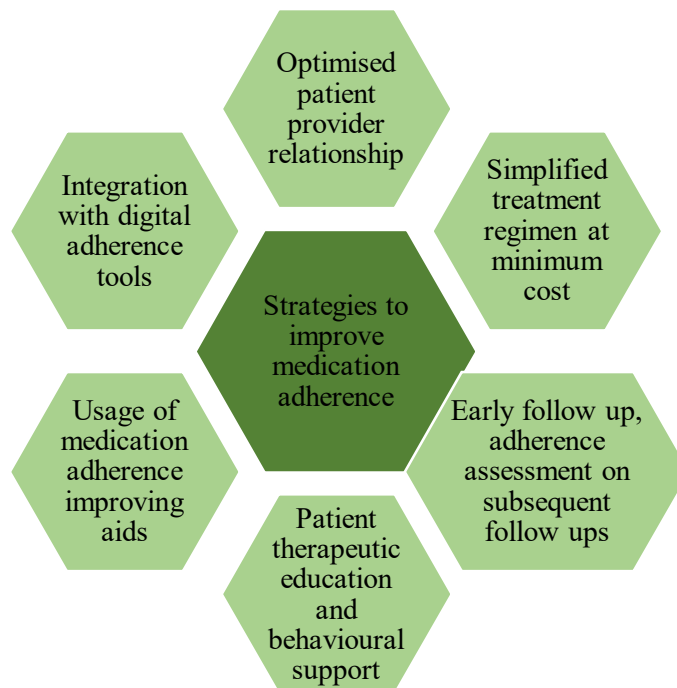


**Figure 1: Multidimensional determinants of medication non-adherence**

To develop a better understanding of the concept of the non-adherence, all potential factors must be considered, screened and selected. The relationship between a health care provider and a patient relies on trust, truth, and collaboration with the aim to achieve mutually agreed treatment goals and therapeutic regimen. Miscommunication between patients and health care provider may lead to compromise in care or disease associated complications. Provider-related factors include barriers in communicating with the patients and/or their caregivers, prescribing complex treatment plans, dosing regimens and lack of coordination, if multiple providers are involved. Health care system factors include limitations in accessing an appropriate provider, inadequate patient provider consultation time, high cost of the treatment, lack of clarity in medication labelling, poor instructions and deficiency in providing appropriate patient education material.

## STRATEGIES TO IMPROVE MEDICATION ADHERENCE

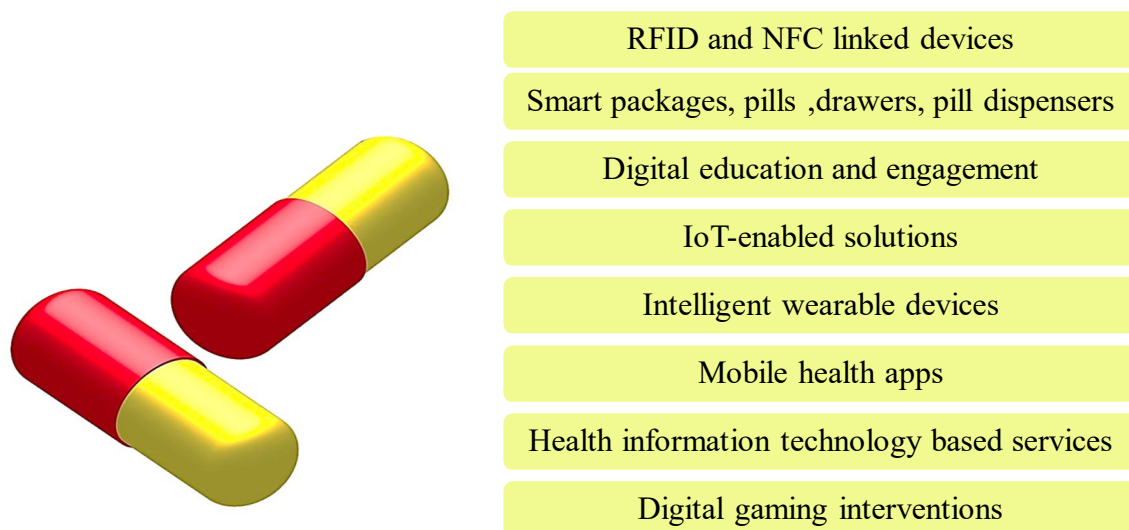
Several approaches have been used for monitoring and increasing adherence, because it leads to both health as well as economic benefits [17]. Medication monitoring or assessment or measurement or evaluation means using a method to observe if the patient has taken the medication or not. On the other hand, intervention here refers to the means for increasing adherence or correcting it, once the fault is detected. Majority of elderly patients and those with chronic diseases such as hypertension, diabetes, and asthma are not adherent. Patients, health care providers, and health care system, all have a role in optimizing medication adherence. Improvement in medication adherence takes time and may be brought about by a single intervention or a combination of various techniques. Figure 2 summarises the various strategies to improve medication adherence.



**Figure 2: Strategies to improve medication adherence**

First and foremost, the health care providers should involve the patient in decision making at the level of prescribing, whenever possible, so that they have a sense of partnership in the treatment plan. Medication regimen management should be based on individual patient's characteristics and done in the most simplified manner possible. Patient education with health educators is another key component of assessing and improving medication adherence. Communication between patient-pharmacist, patient-physician through personalised counselling sessions for addressing the fears and concerns of the patient regarding side effects, adverse drug reactions, and improved cognition of medication and treatment carries prime importance. Clear medication related information to patients should be given regarding the treatment regimen. Patient medication counselling should be accompanied with detailed written information about medicines and adherence improving aids such as medication charts, pill boxes etc. Behavioural interventions are aimed at changing a patient's behaviour toward treatment by the use of cognitive-behavioural techniques, therapies focused on dysfunctional emotions, promotion of healthy lifestyles, and positive changes toward symptoms and regimen [9]. Regular patient follow-up is vital to improve the medication adherence. Telephone calls or alerts, in-person follow-up visits for disease monitoring and refill reminders may be used. Adherence can be assessed by direct and indirect methods during consequent follow ups. The effectiveness of medication adherence aids used if any, barriers related to adherence should be assessed, problems addressed, and informed to patient by the health care team.

With the advancement of technological innovations in health care, digital tools are now-a-days emerging to monitor and increase patient's medication adherence. Digital tools may range from simple reminders to take the medication to smart devices with health apps, or integrated with activity tracking devices or a smart pill or a stand-alone medical device to administer the treatment. Figure 3 depicts the various types of technological innovations for assessing and improving medication adherence.



**Figure3: Technological innovations for assessing and improving medication adherence**

### **DIGITAL TECHNOLOGY TO IMPROVE MEDICATION ADHERENCE**

With the upsurge in the access and usage of mobile phones and penetration of internet, digital adherence technologies have shown a positive impact on medication adherence in patients with diabetes, hypertension, TB and HIV [27-32]. These smart solutions are based on cellular communication or other form of innovations which can be integrated with internet of things to perform a variety of functions, including reminding patients to take medications, digitally recording of medicines taken, compiling and managing dosing histories, for the use of healthcare providers in identification and intervention on non-adherence. Majority of the digital tools provide comprehensive solutions to the patient in their complete health care journey in addition to managing treatments and medication by extending full support in providing education, motivation, monitoring and evaluation resulting in holistic and enhanced patient care. In comparison to manual methods such as direct biochemical approach, where the patient is required to report to a centre for blood or urine testing with associated interventions acting as a great burden on them, digital technology provide non-invasive, useful and simple solutions to monitor and promote the medication adherence, nevertheless they are usually expensive. The following section describes the various ways in which digital technology is used to increase medication adherence.

#### **Radio frequency identification**

Radio frequency identification (RFID) technology is a wireless system that make use of radiofrequency waves to transmit and receive data and is useful for uniquely identifying an object. RFID system comprises of a tag and a reader and because of its small size, it can be combined with various physical forms. RFID works by placing a physical tag on an object that uses radio waves to send data such as location, time, etc. to a remote reader. In the health care ecosystem, RFID technology has found application in billing, tracking inventory, ensuring drug safety, blocking supply chain of counterfeit medicines, monitoring and improving medication adherence. RFID technology can be integrated with medication labels and blister packaging containing pills for identification of patients and tagging individual medication containers to ensure that the right medication treatment is received by the right patient in the health care settings [1, 16, 26, 24, 31].

#### **Near Field Communication**

Near Field Communication (NFC) is an extension of RFID technology, that provides two-way communication process between two compatible devices such as an NFC tag and a smart phone. NFC tags consist of small chips for storing data and can be incorporated into stickers, labels, packs etc. The smart phones can read this data from a short range. In health care, NFC can be integrated into pharmaceutical labels, packages, delivery devices and implemented using smart devices, to trace the consumption of medication by the patient together with keeping the record of each dose taken [22]. NFC enables the monitoring of the medication intake schedule by the caregivers, prescribers and pharmacies. NFC tags can be attached to a drug delivery device, like an auto injector or an inhaler for medication adherence. Tapping a tagged device with a smart phone, can further create a link to medication guides, helpful information and usage videos for the patient.

### MHealth and mobile health application (app)

MHealth is an expanding field, and as per WHO (2011), is defined as a public health care service delivery, supported by wireless and digital technology using mobile devices. M- health interventions are used for the improvement of health outcomes, health care services and research. A mobile health application (app) is a software created for its usage on mobile devices like smart phones, tablets for delivering health information and communication technologies in the support of health fields using images, video, music, word processing and internet service. These may be connected to wearable's.

The advantages of using mobile health applications includes the ease and simplicity of usage, cost effectiveness, broad reach and diverse user friendly features for offering holistic health care. Just one touch can give access to health and medication related knowledge, remote review of records, interaction with other users and healthcare providers in addition to receiving notifications and reminder messages about medication. Examples include Care4Today®, Health Assistant, Mymeds, Medhelperetc. Another benefit is that it can be connected to various smart drug delivery devices or dispensers via Bluetooth or NFC technology. Mobile applications are dynamic in nature with continuous addition of new features and updates for improving the existing apps. Smart phones based health applications can be used in a number of ways to improve medication adherence. They can alert the patients when to take their medications, record the event to their history, or use gamification, or engage the patient, to monitor and promote medication adherence especially for chronic diseases. The marketed is flooded with varied and numerous mobile health apps, however, there is still a long way for MHealth to be universally adopted in routine clinical practice. Table 1 summarises features of commonly used mobile adherence apps.

**Table 1: Features of commonly used mobile medication adherence apps**

Mobile adherence app	Reminder of doses	Sharing information with health care providers	Education	Refill alerts	Tracking dose history	Gamification	Free of Cost
Dosecast (Medication scheduler)	√	√	X	√	√	X	√
Medisafe (Virtual pillbox)	√	√	√	√	√	X	√
Mango Health (Medication manager)	√	X	√	√	√	√	√
Round Health (Medication Organiser)	√	X	X	√	√	X	√
MyTherapy (Pill Reminder)	√	X	√	√	√	X	√
CareZone (Simplified Medication manager)	√	√	√	X	X	X	√
Pillboxie ( Pill reminder)	√	X	√	X	X	X	√
Meds360° (Medication manager)	√	√	√	X	√	X	√

### Smart Package systems

Smart Package systems such as smart blisters and high tech strip packaging are pharmaceutical packages which are designed to track the patient's action of taking out a pill from them. The design of smart blister package system is such that with each dose removed, an individual event is recorded thereby eliminating the chances of patient opening the pack out of curiosity [29]. Another feature in the smart package is to collect the information regarding rupturing time of the package, medication category and name, location etc. These smart blisters can be linked to patient's mobile phones to serve as pill reminders (Morak J et al, 2012). They may be linked to mobile phones of prescribing physician too. Thus, medication adherence monitoring can be done by both the patient as well as the prescriber. Smart package systems are beneficial for patients who take multiple drugs. These smart packages may also be linked to a pharmacy. However, they can be very expensive and cannot find out if the pill was actually consumed after being taken out. Examples of smart packs are CpaX™ connected medication adherence packaging and Schreiner MediPharm's smart blister pack and wallet. CuePath innovation provides one such solution, which transforms ordinary bubble packs into smart packs. The patient's medication is pre-packed by a

pharmacist and whenever he burst the bubble to take the medication, the event is recorded. In addition, the caregivers can monitor the usage via mobile app to track the patient's adherence.

### Smart pill bottles

These devices can monitor the adherence with the help of sensors in the cap, which are able to detect when the bottle is opened, or by means of sensors in the bottle itself, which is based on determination of weight of the pills that are remaining. They are easy to use, but they are expensive, and does not indicate absolute adherence. Literature indicates that smart pill bottle together with pharmacist intervention has improved adherence in patients with multiple myeloma [21]. Similar results have been obtained using smart pills with mobile application in breast cancer survivors [24].

### Medication event monitoring system (MEMS)

MEMS is an intelligent medication device used to monitor the medication adherence. The MEMS can be customised as a cap that fits on standard medicine bottle or can be embedded in metered dose inhalers to record and store number of dosing events. MEMS coupled with other approaches such as counselling, motivational messages, reminder alerts may be useful in promoting adherence [11, 14].

### Smart pill dispensers

These devices include various features such as voice assistants, cameras, alarms or lights to indicate the time of taking medication, along with automatically dispensing the medication. Smart pill dispensers can be very expensive devices and may not be able to track absolute adherence, nevertheless they can meet a variety of patient needs and can provide remote access to health care provider. RxPense® is a smart pill dispenser for blister packaged medications, designed specifically for geriatric patients and patients with chronic diseases. RxPense® can also be used to automate the dispensing of DisPill® and Eco-Pill™ packaged medications. Table 2enlists some of the digital adherence marketed products with their salient features.

**Table 2: Commercial digital adherence products**

Digital Adherence Marketed Product	Features	Reference
Airduodigihaler (Smart Inhaler)	Tracks and records dosing when the cap is opened or inhaled Provides feedback on inhalation instantly Shares data with health care providers	Available: <a href="https://www.airduodigihaler.com">https://www.airduodigihaler.com</a>
Elliegrid (Mobile app and pill organizer)	Connects pill box via Bluetooth to mobile app Program smart alarms Receive notifications when number of pills are running low Reminders available when it is time to take the medication Alerts for pills that are outside of box Access patient compliance report daily	Available: <a href="https://elliegrid.com">https://elliegrid.com</a>
evriMED1000 (MERM) (Smart Dispenser)	Holds up to a month's supply of TB medication and is in sync with Wisepill cloud service Equipped with mobile phone communication chip to send reminder text messages Records medication history Can be customised for individual patient	Available: <a href="https://www.wisepill.com/evrimed">https://www.wisepill.com/evrimed</a>
inPen (Smart insulin delivery pen)	Uses Bluetooth technology to send dose information, and reminders to a mobile app Offers dose recommendations and tracking of doses Delivers insulin doses Shares reports with the healthcare team	Available: <a href="https://www.companionmedical.com/inpen">https://www.companionmedical.com/inpen</a>
Aidia Smart Bottle (Smart pill bottle)	Smart adherence system using bottles and devices to track doses Provides real time care support and connect with pharmacy Remind with music and light indicating the time to take the medication Alerts if doses are missed	Available: <a href="https://adheretech.com/">https://adheretech.com/</a>
Glowcap (Intelligent pill cap)	Fits on standard prescription bottles Provides visual, audible, text messages ,mobile phone alerts to promote medication adherence Every time, the pill bottle is opened ,it records adherence data and send periodic progress reports to patients, their caregivers and health care providers	Available: <a href="https://mantadesign.com/work-pill-dispenser/">https://mantadesign.com/work-pill-dispenser/</a>

## **Smart Drawers**

Smart drawers are designed to scan the inventory (medication) which is stored inside them, identify them, recognize the opening and shutting of the drawer, monitor the patient's drug taking activity as well as record these activities with a timestamp. Integration of smart drawer with Internet of Things (IoT) can be used to monitor the adherence, alert the patients and their caregivers when the protocols of the prescribed therapeutic regimen are not being followed [3, 122].

## **Bio-ingestible sensors and drug-device combination**

These devices are pill-sized electronic chips embedded in oral medication, which on swallowing by the patients alerts their smart phone. This data can be then sent to the health care provider to find out if the patient has taken medication or not. Abilify Mycite is an oral tablet containing Aripiprazole with a bio-ingestible sensor for tracking the adherence. It was the first bio-ingestible product to be approved by FDA in 2017 [16]. Bio-ingestible sensors can only track adherence, and not improve it. More than 80% medication adherence have been reported in clinical trials performed using bio-ingestors for uncontrolled hypertension with type II diabetes and mental illness [13, 18]. Examples of integration of adherence monitoring with drug administration devices includes smart inhalers and electronic auto-injector devices (Choi SH et al, 2018). Literature indicates that these "Drug-device combination" enhance medication adherence, although there are other needs which yet remain unmet [3, 35].

## **Digital education, engagement and gaming**

Guiding and engaging the patients throughout their healthcare journey with the aid of digital tools enhance communication with healthcare providers and adherence to their medication thus simplifying the process, decreasing cost of readmission and relapse and leading to positive therapeutic outcomes. Patient Engagement solutions by Elsevier's educates patients by giving them access remotely to evidence-based information, prescribers trust, in interactive and patient-friendly ways. This gives them a sense of engagement and involves the patients actively in treatment and care. Presently tele-health or tele-monitoring are playing a key role in affecting adherence. These health information technology services are non-invasive services that combines digital information and communication technologies to remotely access patients' health and provide care and support to them, promote adherence, especially for the management of chronic diseases [6]. Meds OnCue by VUCA Health is an innovative digital patient education platform for providing information to patients through prescription specific short duration videos that can be accessed from a QR code on the prescription label through their smart phones. These video includes their medication, dosage, frequency and the most common side effects. It instructs the patients to contact their physicians or pharmacists for managing side effects and encourage them to stick to their complete treatment regimens by providing medication reminders and also reinforces safe medication use. There is also provision for certain Pharmacy Incentive IOT based programs offered by some companies, for example Cigna, through its CoachRx service: an interactive website, helps its members to identify the barriers of non-adherence, provides educational resources about ways to improve adherence and send daily reminders text messages, voicemails, or emails. Walgreens' Balance Rewards for Healthy Choices provide a set of web, app and text-based programs for improving medication adherence, promoting engagement and encouraging immunizations.

Interactive gamification solution related to health activities is a promising approach to increase adherence. Gamification refers to applying game with playing features such as points, competition, levels, rewards etc. to promote patients' engagement, education and motivation towards their therapy [24]. Health Prize Technologies uses gamification and engagement for motivating the patients to support health literacy, increase adherence and improve health outcomes with the help of videos, quizzes, surveys, rewards etc.

## **CONCLUSION**

Improving medication adherence requires a continuous multi-factorial approach that is personalised as per the needs and disease state of the patient. Digital adherence tools such as m-health apps, smart pills, smart packages and dispensers are changing the patient's healthcare path with their use ranging from appointments, consultation, integration in decision-making, tailored regimens, medication dispensing, monitoring to learning about routine medicine management. They can affect the medication management at all levels including physicians, pharmacists, healthcare systems, individual patients and their caregiver. A thorough understanding of on the part of the healthcare providers, stricter regulations and affordability is required for a wide recommendation and acceptance of digital adherence tools by the patients. Pharmacists are an integral member of the healthcare team and considered as one of the most trusted and accessible healthcare professionals. While dispensing medications and refilling prescriptions, the interaction between patients and pharmacists can lead to understanding of the patients' thoughts about disease and expectations from the treatment. Pharmacists are in a unique position to positively influence

them and manage factors such as dexterity, vision and cognition that may affect adherence. Digital solutions coupled with human interventions holds immense potential to address the problem of medication non-adherence.

### CONFLICT OF INTEREST

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### REFERENCES

1. Ajami S, Rajabzadeh A. Radio Frequency Identification (RFID) technology and patient safety. *J Res Med Sci.* 2013;18(9):809-813
2. Anghel LA, Farcas AM, Oprean RN. An overview of the common methods used to measure treatment adherence. *Med Pharm Rep.* 2019 Apr;92(2):117-122.
3. Becker E, Metsis V, Arora R, Vinjumur J, Xu YR, Makedon F. Smart Drawer: RFID-based smart medicine drawer for assistive environments. *Proceed IntConfPervasive TechnolRelat Assist Environ.* 2009;49:1-8
4. Brennan V, Mulvey C, Greene G, Hale EM, Costello RW. A Clinical Perspective on the Role of Electronic Devices in Monitoring and Promoting Adherence in Airways Disease. *Front Med Technol.* 2021 Apr 12;3:604475.
5. C, Joseph & Mathews, Kelly & Sredzinski, Eric. (2019). Effect of a Smart Pill Bottle and Pharmacist Intervention on Medication Adherence in Patients with Multiple Myeloma New to Lenalidomide Therapy. *Journal of managed care & specialty pharmacy.* 25. 1244-1254. 10.18553/jmcp.2019.25.11.1244.
6. Calthorpe RJ, Smith S, Gathercole K, et al. Using digital technology for home monitoring, adherence and self-management in cystic fibrosis: a state-of-the-art review. *Thorax* 2020;75:72-77.
7. Chakrabarti S. What's in a name? Compliance, adherence and concordance in chronic psychiatric disorders. *World J Psychiatry.* 2014 Jun 22;4(2):30-6.
8. Choi SH, Wang Y, Conti DS, Raney SG, Delvadia R, Leboeuf AA, et al. Generic drug device combination products: regulatory and scientific considerations. *Int J Pharm.* (2018) 544:443-54. doi: 10.1016/j.ijpharm.2017.1
9. Costa E, Giardini A, Savin M, Menditto E, Lehane E, Laosa O, Pecorelli S, Monaco A, Marengoni A. Interventional tools to improve medication adherence: review of literature. *Patient Prefer Adherence.* 2015 Sep 14;9:1303-14.
10. Cramer JA, Roy A, Burrell A, Fairchild CJ, Fuldeore MJ, Ollendorf DA, et al. Medication compliance and persistence: terminology and definitions. *Value Health.* 2008;11:44-47.
11. Diaz E, Levine HB, Sullivan MC, et al. Use of the Medication Event Monitoring System to estimate medication compliance in patients with schizophrenia. *J Psych Neurosci.* 2001;26(4):325-329.
12. DiMatteo MR, Giordani PJ, Lepper HS, et al. Patient adherence and medical treatment outcomes: a meta-analysis. *Med Care.* 2002;40(9):794-811
13. Frias, J.; Viridi, N.; Raja, P.; Kim, Y.; Savage, G.; Osterberg, L. Effectiveness of Digital Medicines to Improve Clinical Outcomes in Patients with Uncontrolled Hypertension and Type 2 Diabetes: Prospective, Open-Label, Cluster-Randomized Pilot Clinical Trial. *J. Med. Internet Res.* 2017, 19, e246.
14. Haberer J. Medication event monitoring systems, In: Gellman MD, ed. *Encyclopedia of Behavioral Medicine.* Cham: Springer; 2020.
15. Hugtenburg JG, Timmers L, Elders PJ, Vervloet M, van Dijk L. Definitions, variants, and causes of nonadherence with medication: a challenge for tailored interventions. *Patient Prefer Adherence.* 2013 Jul 10;7:675-82.
16. Kane, J.M. Comments on AbilifyMyCite. *Clin. Schizophr. Relat. Psychoses* 2018, 11, 205-206.
17. Kini V, Ho PM. Interventions to Improve Medication Adherence: A Review. *JAMA.* 2018;320(23):2461-2473. doi:10.1001/jama.2018.19271
18. Kopelowicz, A.; Baker, R.A.; Zhao, C.; Brewer, C.; Lawson, E.; Peters-Strickland, T. A multicenter, open-label, pilot study evaluating the functionality of an integrated call center for a digital medicine system to optimize monitoring of adherence to oral aripiprazole in adult patients with serious mental illness. *Neuropsychiatr. Dis. Treat.* 2017, 13, 2641-2651.
19. Kurnianingsih, Kurnianingsih & Anif, Muhammad & Helmy, & Putra, Andri & Ernawati, Dwi & Prabuwo, Anton Satria. (2015). HoMeTrack: RFID-based localization for Hospital Medicine Tracking System. 10.1109/ICITACEE.2015.7437848.
20. Morak J, Schwarz M, Hayn D, Schreier G. Feasibility of mHealth and Near Field Communication technology based medication adherence monitoring. *Annu Int Conf IEEE Eng Med Biol Soc.* 2012;2012:272-275.
21. Mrosek, R.; Dehling, T.; Sunyaev, N. Taxonomy of health IT and medication adherence. *Health Policy Technol.* 2015, 4, 215-224.
22. Osterberg L, Blaschke T. Adherence to medication. *N Engl J Med.* 2005 Aug 4;353(5):487-97.
23. Pankaj Pal, Sharda Sambhakar, Vivek Dave, Shailendra Kumar Paliwal, Sarvesh Paliwal, Monika Sharma, Aadesh Kumar, Nidhi Dhama, A review on emerging smart technological innovations in healthcare sector for increasing patient's medication adherence, *Global Health Journal*, Volume 5, Issue 4, 2021, Pages 183-189,
24. Park, Hyang Rang RN, MS; Kang, Hee Sun PhD, RN; Kim, Soo Hyun PhD, RN; Singh-Carlson, Savitri PhD, RN Effect of a Smart Pill Bottle Reminder Intervention on Medication Adherence, Self-efficacy, and Depression in Breast Cancer Survivors, *Cancer Nursing*: October 12, 2021 - Volume - Issue - doi: 10.1097/NCC.0000000000001030
25. Ridho A, Alfian SD, van Boven JFM, Levita J, Yalcin EA, Le L, Alffenaar JW, Hak E, Abdulah R, Pradipta IS. Digital Health Technologies to Improve Medication Adherence and Treatment Outcomes in Patients With Tuberculosis: Systematic Review of Randomized Controlled Trials. *J Med Internet Res.* 2022 Feb 23;24(2):e33062.



26. Rosenbaum BP. Radio Frequency Identification (RFID) in Health Care: privacy and security concerns limiting adoption. *J Med Syst.* 2014;38(3):19.
27. Sabin LL, Bachman DeSilva M, Gill CJ, Zhong L, Vian T, Xie W, Cheng F, Xu K, Lan G, Haberer JE, Bangsberg DR, Li Y, Lu H, Gifford AL. Improving Adherence to Antiretroviral Therapy With Triggered Real-time Text Message Reminders: The China Adherence Through Technology Study. *J Acquir Immune Defic Syndr.* 2015 Aug 15;69(5):551-9.
28. Simone Orcioni, Roberto Pellegrini, Ralf Seepold, Maksym Gaiduk, Natividad Martínez Madrid, Massimo Conti, Medication adherence supported by mHealth and NFC, *Informatics in Medicine Unlocked*, Volume 23, 2021, 100552
29. van Onzenoort HA, Neef C, Verberk WW, van Iperen HP, de Leeuw PW, van der Kuy PM. Determining the feasibility of objective adherence measurement with blister packaging smart technology. *Am J Health Syst Pharm* 2012 May 15;69(10):872-879.
30. Vervloet M, van Dijk L, de Bakker DH, Souverein PC, Santen-Reestman J, van Vlijmen B, van Aarle MC, van der Hoek LS, Bouvy ML. Short- and long-term effects of real-time medication monitoring with short message service (SMS) reminders for missed doses on the refill adherence of people with Type 2 diabetes: evidence from a randomized controlled trial. *Diabet Med.* 2014 Jul;31(7):821-8.
31. Vignesh Ramachandran, Arjun M. Bashyam & Steven R. Feldman (2019) A new spin on improving adherence, *Journal of Dermatological Treatment*, 30:7, 631-632, DOI: 10.1080 /09546634. 2019.1652955
32. Wechkunanukul K, Parajuli DR, Hamiduzzaman M. Utilising digital health to improve medication-related quality of care for hypertensive patients: An integrative literature review. *World J Clin Cases.* 2020 Jun 6;8(11):2266-2279.
33. World Health Organization. (2003). Adherence to long-term therapies : evidence for action / [edited by Eduardo Sabaté]. World Health Organisation . <https://apps.who.int/iris/handle/10665/42682>
34. World Health Organization (WHO) Global Observatory for eHealth, mHealth. *New Horizons for Health through mobile Technologies.* Geneva: World Health Organization (2011). p. viii.
35. Zabczyk C, Blakey JD. The Effect of Connected "Smart" Inhalers on Medication Adherence. *Front Med Technol.* 2021 Aug 18;3:657321.
36. Available: <https://www.airduodigihaler.com>
37. Available: <https://elliegrid.com>
38. Available: <https://www.wisepill.com/evrimed>
39. Available: <https://www.companionmedical.com/inpen>
40. Available: <https://adheretech.com/>
41. Available: <https://mantadesign.com/work-pill-dispenser/>

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