The Promise of New Technologies in an Age of New Health Challenges
A.J. Maeder et al. (Eds.)
© 2016 The authors and IOS Press.
This article is published online with Open Access by IOS Press and distributed under the terms of the Creative Commons Attribution Non-Commercial License 4.0 (CC BY-NC 4.0).
doi:10.3233/978-1-61499-712-2-31

# Current Trends in Electronic Medication Reminders for Self Care

Kerry Y FANG<sup>a,1</sup>, Anthony J MAEDER<sup>b</sup> and Heidi BJERING<sup>a</sup> <sup>a</sup>School of Computing, Engineering and Mathematics, Western Sydney University Campbelltown NSW Australia <sup>b</sup>School of Health Sciences, Flinders University, Bedford Park SA Australia

**Abstract.** Poor adherence to medication can lead to negative health outcomes and increased financial burdens. We present a literature review on electronic medication reminders used for medication adherence in self care settings, to identify current and possible future trends. A structured PubMed search based on extracted MeSH terms provided a total of 45 publications which were identified as most relevant. Three main categories of electronic solutions were identified: mobile phone reminders, inhome electronic reminder devices, and portable reminder devices.

Keywords. Reminder systems, medication adherence, self care

# Introduction

The problem of poor adherence to medication regimens occurs all around the world, and various strategies have been developed and applied in order to address this. Improved medication adherence helps to achieve better health outcomes for the patients and reduce financial burdens on the healthcare system by reducing adverse health incidents [1]. Forgetfulness in taking medication is a common cause for poor adherence; additionally as a person ages, the list of medications prescribed by healthcare professionals grows, and so does the number of times per day at which they must be taken.

Existing evidence-based medication adherence interventions for self care settings requiring human carer involvement are often disadvantaged by high-resource delivery needs and impracticality for everyday clinical practice settings [2]. Consequently a recent popular strategy has been the use of technology-based interventions to improve medication adherence. These interventions are generally realized through the use of information and communications technology-driven electronic reminders to inform patients of the time to take their medication, and sometimes also the dosage. Electronic reminders are defined as automatically generated or sent reminders, without personal human contact between the healthcare provider and the patient. These reminders may occur independently of the actual medication or may be associated with various medication storage and handling devices.

<sup>&</sup>lt;sup>1</sup>Corresponding Author.

This paper aims to provide a literature review on electronic medication reminders used for medication adherence in order to identify the current and future trends. This paper only reviews contributions in the scientific literature and so materials and research produced by organisations outside of the associated commercial or academic publishing channels were not considered.

# 1. Background

Inconsistent and interrupted adherence behaviour can lead to negative consequences on the subject of care, especially for elderly patients and patients with serious health conditions. Studies have shown that the true rate of medication adherence in self care settings in developed countries is typically only about 50% [3, 4].

Non-adherence to medication is considered to be a major public health problems, which can lead to financial burden upon the healthcare systems [5], as non-adherence can result in hospitalisations, re-hospitalisations, and nursing home admissions [6]. Among the population, elderly people are more at risk of the consequences of non-adherence in comparison to younger people due to their age and health complications. The diminished visual acuity, decreased physical strength, poor coordination, and other cognitive deficits associated with ageing makes their daily activities, including medication taking, increasing laborious [7]. Most non-adherence (especially with elderly people) is presumed to be unintentional, often caused by forgetfulness or carelessness. However younger adults can also forget their medication unintentionally, due to busy lifestyle. Unintentional non-adherence is often influenced by patient characteristics, age, treatment factors, and patient-provider issues [8].

Drug-related factors and patient-related factors play an important role in medication adherence are [9]. Drug-related factors include complex medication regimens, adverse effects and the number of concurrent drugs. Patient-related factors include cognitive ability, health knowledge and beliefs about the drugs [10]. It is important for healthcare professionals to determine the cause of non-adherence in order to apply the most suitable strategy to help to improve adherence. Often this involves applying a combination of strategies instead of a single strategy, in order to achieve the best adherence outcome.

# 2. Methodology

The goal of this paper was to collect and analyse publications on electronic medication reminders used for medication adherence in self care settings, to identify the current and possible future trends. PubMed was used as the primary tool for searching the publications, and all of the publications included were published since 2007, ensuring that the most current trends were considered. The choice of limiting the search to PubMed was made on the basis that terminology for the topic of interest would be more consistent in this environment, as compared with very broad related vocabulary likely to occur in the more general science/engineering arena.

MeSH was used to refine the search terms for use in PubMed. Three primary concepts that were related to the scope of this research were identified as initial query construction terms: "medication reminder", "medication adherence" and "self care". The term "medication reminder" did not occur directly in MeSH, but when this was reduced to "reminder", MeSH suggested the term "reminder systems" defined as "systems used to prompt or aid the memory". The qualifier "electronic" was not used to limit "reminder systems" as it is not used in this context within MeSH. By examining the paths to the terms in the MeSH terminology, it was found that "reminder systems" was related to communication and information systems (and not to healthcare), "medication adherence" was related to patient compliance (through health behaviour and patient acceptance), and "self care" was related to therapeutics and rehabilitation (through health services). Table 1 shows the terms and paths discovered.

MeSH Search Term		Paths	
Reminder Systems	1.	Information Science Category/Information	
		Science/Communication/Reminder Systems	
	2.	. Information Science Category/Information Science/Medical	
		Informatics/Medical Informatics Applications/Information	
		Systems/Reminder Systems	
Medication Adherence	edication Adherence 1. Psychiatry and Psychology Category/Behavior and Behav		
		Mechanisms/Behavior/Health Behavior/Patient	
		Compliance/Medication Adherence	
	2.	Health Care Category/Health Care Quality, Access, and	
		Evaluation/Delivery of Health Care/Attitude to Health/Patient	
		Acceptance of Health Care/Patient Compliance/Medication Adherence	
Self Care 1.		Analytical, Diagnostic and Therapeutic Techniques and Equipment	
		Category/Therapeutics/Self Care	
	2.	Health Care Category/Health Care Facilities, Manpower, and	
		Services/Health Services/Rehabilitation/Self Care	

Table 1. MeSH Search terms and paths

Once these preferred MeSH search terms were determined, PubMed searches were conducted (at 1-Jan-2015) using them to find publications to provide a baseline for future searches. Since "Reminder Systems" is the primary topic in this review, it is regarded as a compulsory term, and it is accepted that additional terms might be from either of the two groups "Medication Adherence" and "Self Care". A search requiring all three MeSH terms in this combination only resulted in 228 papers, as shown in Table 2.

Table 2. PubMed search results based on MeSH terms

PubMed Search String	# Publications
Reminder Systems [MeSH Terms]	2330
Medication Adherence [MeSH Terms]	8475
Self Care [MeSH Terms]	41001
Reminder Systems [MeSH Terms] AND (Medication	228
Adherence [MeSH Terms] OR Self Care [MeSH Terms] )	

By examining the titles and abstracts of the first 500 papers in the query results of the three independent MeSH term searches in Table 2, commonly used related terms were obtained for each group. These terms were verified by two expert reviewers to ensure accuracy and were then used to conduct PubMed Title/Abstract searches. Table 3 shows results found from these searches, compared with the initial MeSH based searches. From this table, it can be seen that all of the most common related terms produce substantially fewer results (all below 23%) for Title/Abstract searches, compared with the searches based on the preferred MeSH terms. Addition of further (less common) related terms would be most unlikely to yield higher rates than these. It was therefore decided to adopt the original MeSH based search results for further analysis.

	Related terms	# Publications (% MeSH)
Reminder system	Medication reminder	35 (1.5%)
	Clinical reminder	83 (3.6%)
	Electronic reminder	44 (1.9%)
	Computerized reminder	49 (2.1%)
	Automated Communication	12 (0.5%)
Medication adherence	Medication compliance	1130 (13.3%)
	Drug compliance	698 (8.2%)
	Drug adherence	407 (4.8%)
	Patient autonomy	1576 (18.6%)
Self care	Self-management	9190 (22.4%)
	Self-monitoring	4337 (10.6%)
	Self-medication	2486 (6.1%)
	Self-treatment	1008 (2.5%)
	Self-administration	7082 (17.3%)
	Home-based care	501 (1.2%)

Table 3. Title/Abstract related term search results.

As a result of the combined MeSH based search a total of 228 publications were found. Limiting the search to publications within 10 years resulted in 201 papers being retained. Within these, analysis of the titles of the paper revealed 108 papers were irrelevant, as the titles were either related to only general medication adherence issues, or related to reminder techniques but not specifically electronic reminder systems or devices: this resulted in 93 relevant publications based on title. These 93 publications were then further analysed based on reading of their abstracts, from which 53 papers were excluded as they either lacked hands-on trials of actual implemented reminder systems or devices in order to determine their effectiveness, or the reminder techniques were not related to the scope of this paper. This resulted in a set of 40 publications being chosen as most relevant to the review.



Figure 1. Diagrammatic view of the selection process

Within the 40 publications, 7 of the full publications were not available through the institutional library service. Of the remaining 33 publications, 7 were systematic reviews related to electronic medication reminders [15, 30, 31, 32, 37, 45, 55]. It was noted that all of the 33 publications chosen were published after the year 2007 without additional date constraints applied to the PubMed search, which further ensured that the most current trends were considered. Detailed content analysis was then conducted based on reading of the full papers for these 33 publications. Reference searches were also done on the 33 publications to find any commonly cited works which had been missed, which located 12 additional relevant papers to be included in the overall analysis (i.e. 45 papers in total). Figure 1 above shows the diagrammatic view of this selection process.

# 3. Analysis

Based on the results from the PubMed search and reference search, 45 publications related to electronic reminder systems for medication adherence in self care were read and analysed. This led to a broad summary of the current trends into 3 categories: mobile phone reminders, in-home electronic reminder devices, and portable reminder devices.

#### 3.1. Mobile phone reminders

Mobile phones are devices that can support electronic reminder systems, as they allow constant access to communication and information and can perform many computational tasks. Their popularity has grown exponentially over the past few years so it can be assumed that they are now widely available and used across the population. Mobile phones provide ubiquity, accessibility and familiarity for users, which in turn has the ability to make their long-term use more sustainable over other electronic devices [11], and as such can be used as very convenient reminder devices that allow various degrees of personalization based on preferences [12]. One study has shown that a mobile-phone-based medication reminder system contributed positively to improving medication adherence [13]. Recent mobile phone contributions in the field of interest have focused on usage with internet connectivity. There are 3 types of reminding services that can be use with mobile phones: phone call/SMS services, reminder apps, and built-in alarms.

Phone calls and SMS (Short Message Service) reminder services were widely used even before mobile phones became popular. They are typically done by calling or texting the patients on to remind them to take their medications, often automatically from a service provider [14]. SMS reminding is currently increasingly being implemented in interventions aimed at improving medication adherence, due to high mobile device penetration and cheap cost [15]. One study on the effectiveness of SMS reminders shows that the rate of missed dose was decreased by 90.1% for participants in an intervention group that received SMS medication reminders [16].

Various studies targeting a variety of health situations have shown that SMS interventions help to improve medication adherence and behaviour and can be useful in measuring adherence. Studies on the effects of SMS reminder on medication adherence for patients with chronic diseases, such as diabetes, Parkinson and mental illness have shown to improve medication adherence [17, 18, 22]. SMS-based medication reminders have also shown to improve adherence for patients with infectious and viral disease, such as HIV/AIDS and tuberculosis [19-21, 23, 24, 31, 32].

One study focused on the effects of daily SMS reminder on patients with asthma, and the result shows that daily text message reminders are associated with increased adherence to anti-asthmatic medication [25]. A study on automated telecommunication-based reminders with once-daily glaucoma medication show that daily text or voice message improve adherence rate from 53% to 64% [26]. SMS is considered personal, socially acceptable, inexpensive and is accessible to patients irrespective of their geographical or socioeconomic barriers [27].

Personalized SMS reminders sent at a pre-set time have been shown to improve medication adherence significantly and reduce rejection episodes for paediatric recipients of liver transplants [28]. Interactive text message response (ITR) is an example of text messaging reminding where patients receive personalized daily short message system reminders with a follow up message about an hour later asking if they have taken their medication and directing a response via return text message [29].

One systematic review on the effectiveness of interventions using electronic reminders on patients taking chronic medication claimed that SMS intervention help to improve medication adherence [15] while another on the scope and effectiveness of text messaging for HIV/AIDS care showed that SMS reminders helped to improve adherence to HIV/AIDS medications [21]. A systematic review on the effectiveness of mobile phone messaging for facilitating self-management of long-term illnesses concluded that these interventions may provide health benefits [30]. However the use of such a service can also have disadvantages, including the risk of inaccurate data input, lack of understanding or misinterpretation of the information, and difficulties in reading for those with poor vision or literacy problems [30]. Another systematic review concluded that SMS reminders help to improve anti-tuberculosis medication adherence [32].

Mobile phone apps are a novel approach to improving medication adherence and behaviour, as they are constantly accessible, easy to use and learn, and have the ability to educate patients and provide medication specific information. Apps are downloaded into a mobile phone, so patients do not need to carry a separate reminder device to remind them to take their medication [33]. The apps can be obtained with little to no cost, and have been proven to be very useful for patients with complex medication regimens [34].

The number of such adherence apps is increasing across platforms such as iOS and Android, and the most popular features are medication reminders, refill reminders, data logs that record adherence which can be uploaded to healthcare professionals, and medication information. One study on the effectiveness of an iPhone app showed that most participants were comfortable sharing information via the app with a health professional, and deemed it useful in reminding and managing their medications [35].

Sometimes users will use only the built-in alarm features of a mobile phone to remind them to take their medication. However this does not work very well for patients who need to take a number of different drugs and doses every day, as they can get confused over which medication to take and how much to take, when the alarm rings.

It has been claimed that combining in-person with automated reminders produces the most effective results for improving medication adherence, clinical outcomes, patient and caregiver satisfaction, as well as improvement in patient-doctor relationship or person-centeredness of care [36]. One systematic review paper concluded that all studies in the review suggest that reminder systems such as text messages, automated phone calls and audio-visual reminder devices help to increase patient medication adherence [37].

# 3.2. In-home electronic reminder devices

Reminder services can be built into a home environment, such as smart homes, for health management and monitoring purposes. It can be beneficial to both the patients and healthcare providers, and especially useful for elderly patients who live alone and have difficulty managing their medications. For the providers, an automatic monitoring system with sensors will free up labour from 24/7 physical monitoring, thus reducing labour costs and increasing health service efficiency. In-home sensors and wearable sensors can monitor changes in the environment and patient's vital signals such as heart rate and blood oxygen levels, which human carers might overlook. The data collected from the sensors can be stored and integrated into a patient's health records for use by healthcare professionals to adjust diagnoses and treatments [38].

The Home Automated Telemanagement system was developed for the computerguided management of patients with ulcerative colitis to monitor their symptoms, medication compliance, quality of life, and educating them on their disease. The system can also be adapted for other diseases such as hypertension, where the same principles can be applied to aid patient adherence in self care. The response of patients to the system within the pilot tests has been positive as it is easy to use and convenient [39].

Recent advances in telehealth technologies have enabled the development of connected devices that can be used in home settings in order to assist with medication management and monitoring [40]. Automatic pill dispensers are sophisticated, computerbased monitoring systems that can be programmed to perform a variety of functions, such as emitting audible or visual alarms, separating medications into compartments and dispensing the correct medication dosage. Some can contact a caregiver by telephone if a medication dosage was not taken within a predefined period. By using an automatic pill dispenser, the medication is locked away so the patient cannot accidentally overdose [41]. One major disadvantage of this device is that it can cost up to \$1000, which is expensive compared to other type of reminder devices. [41]. In a randomized controlled trial of 61 elder patients with chronic illness, an automatic pill dispensing device with an audible medication-taking prompt was found to be superior in enhancing medication adherence in comparison with pre-filled pillboxes after a 6 months trial [42]. An example of such device is the MD.2 medication dispenser, a device that automatically dispenses the pre-loaded medication and gives alerts to patients when it is time to take their medication [43, 44]. A study has shown that dose-dispensing aids, including automated dose dispensing with monitoring system, help to improve adherence in polymedication [45].

Two-way interactive video technology can also be used to monitor medication compliance. Such technology brings virtual medication monitors into people's homes. The virtual caregivers can help to increase social interactions, thus adding to the quality of life. A study of the use of such technology over a sustained period on subjects with mild dementia found that the video-monitored participants' compliance remained stable at a rate of 81% while unmonitored patients' compliance fell by 12% [46].

# 3.3. Portable reminder devices

Portable reminder devices have an advantage over in-home reminder device due to their portability which makes them popular amongst busy individuals. These devices are often small in size so the users can carry the device with them everywhere they go, therefore the reminder service is not restricted to only the in-home environment. Simple reminders

provided by a portable medication reminder device have been reported to improve medication adherence [47]. These portable devices often work by sounding an alarm and sometimes flash lights to remind the patients when it's time to take medications [48].

The electronic pillbox is a widely used and simple portable medication reminder device and is suitable for patients who are not 'tech savvy'. Med-eMonitor is a smart pill container that is capable of cueing the taking of medication, warning the patients when they are taking the wrong medication, recording side effects complaints, and alerting carers of failures to take medication [49, 50]. A study has shown that Med-eMonitor help to improve medication adherence and achieve high satisfaction ratings [51].

The Helping Hand is an electronic monitoring tool that is suitable for blister packages. The reminder system within the Helping Hand consists of LED lights that provide feedback to the user regarding their medication behaviour within the previous week. It also yields a beeping signal to remind patients to take their medication at the correct time. It is easy to use and widely accepted by patients and clinicians [52, 53].

The Alarm Watch is a wristwatch that allows a patient, especially those away from home, to keep track of when their medications are due. The system allows the patient to make multiple daily alarms and an optional alarm instructional text message can also be displayed across the face of the watch. The watch has a vibrate mode so that only the wearer can know that it is time to take medication. There is also an emergency medical alert that can speak for the patients if they are unable to speak for themselves [44].

MedSignals is a device that is smaller than a desktop phone, and can signal pill usage in four different ways: beeps, flashing, text or voice. It can also verbally announce how many pills the user should take and how to take them, and can track patient's medication usage and upload the information to patient's file for use by healthcare professionals [44].

TimeCap fits a conventional prescription medication vial, and contains a digital timepiece that displays the time of day and day of the week when the container was last opened. This helps the patient who forgets when or if they took their most recent dose as they can find out by simply checking the digital timepiece on the cap. The timepiece also contains an alarm that beeps when a dose is due [54].

Results from a systematic review study shows that simple devices that monitor and store adherence records and devices that combine digital displays with audible reminder alarms appeared to be the main characteristics of Electronic Medication Packaging devices most useful for improving medication adherence [55].

# Conclusion

Increasing medication adherence through a reminder system is one of the most common types of behavioural intervention: it targets and is helpful for patients who forget to take their medication unintentionally. Based on the above analysis, mobile phones, in-home electronic devices and portable devices used to communicate reminder messages have been shown to be useful in improving medication adherence and achieve a high user satisfaction, as summarised in Table 4. Based on the three different types of reminder systems identified, we can see that electronic reminder technology has evolved in several parallel streams over the past 10 years. Simple text messages are now moving towards interactivity through interactive voice response messages. Mobile phone apps are also becoming increasingly popular as an effective and convenient way of dose reminding.

Technology	Success Aspect	Criteria offering success
Mobile phone	SMS [15-32]	Short, simple, effective, inexpensive, personal
	Phone call [31]	Personal contact, relationship building
	Applications [33, 34, 35]	Variety of functions, graphic images, cheap
In-home	Smart Home device [38, 39]	Integration to smart homes, automated 24/7 monitoring,
device		reduce labor costs, increase efficiency, data storage
	Automatic dispenser [42-45]	Standalone device, effective, multi-medication dispenser
	Video monitoring [46]	Virtual caregivers, increase social interaction
Portable	Electronic pillbox [49, 50]	Portable, suitable for non-tech-savvy people, easy to use
device	Alarm Watch [44]	Small, portable, wearable
	Helping Hand [51-53]	Portable, suitable for blister package
	TimeCap [54]	Portable, fits conventional medication vial
	MedSignals [44]	Variety of reminder functions, tracking medication usage

Table 4. Overview of the technology and its success factors.

Medication reminding services are now being integrated into smart homes, which could become widely adopted in the future due to the many advantages associated with them. Automatic pill dispensing is also a desirable in-home reminder system, especially for the growing population of elderly people living along in the community, as it not only reminds patient to take their medication, but also helps to avoid accidentally overdose.

Various specialized portable devices like the ones discussed above could become a popular trend in the near future as they are easy to use and learn compared to other technologies that require some level of IT knowledge. Technologies like phone apps, smart home devices, automatic dispensers and video monitoring are also able to link to external systems, for example the pharmacies for medication refill information, or link to their healthcare centre and notify healthcare professionals when needed.

In conclusion, electronic reminder technology provides many benefits such that it is portable, effective, simple, accurate, and can include multiple functions. Each reminder technology has its success aspects and the criteria that enable such success. This paper shows that the current trends of electronic medication reminders should lead to improvements in medication adherence in self care settings, and the increasing opportunities in newer Information Communication Technologies will allow more patients access to such reminder solutions.

#### References

- [1] Sabaté, E. (Ed.). Adherence to long-term therapies: evidence for action. World Health Organization. 2003.
- [2] Haynes, RB., Ackloo, E., Sahota, N., McDonald, HP., & Yao, X. Interventions for enhancing medication adherence. *The Cochrane Library*. 2008.
- [3] Haynes, RB., McDonald, H., Garg, AX., & Montague, P. Interventions for helping patients to follow prescriptions for medications. *The Cochrane Library*. 2002.
- [4] McDonald, HP., Garg, AX., & Haynes, RB. Interventions to enhance patient adherence to medication prescriptions: scientific review. *Journal of the American Medical Association*. 2002; 288(22):2868-2879.
- [5] Vermeire, E., Hearnshaw, H., Van Royen, P., & Denekens, J. Patient adherence to treatment: three decades of research. A comprehensive review. *Journal of clinical pharmacy and therapeutics*. 2001; 26(5):331-342.
- [6] MacLaughlin, EJ., Raehl, CL., Treadway, AK., Sterling, TL., Zoller, DP., & Bond, CA. Assessing medication adherence in the elderly. *Drugs & aging*. 2005; 22(3):231-255.
- [7] Cargill, JM. Medication compliance in elderly people: influencing variables and interventions. *Journal of advanced nursing*. 1992; 17(4), 422-426.
- [8] Lehane, E., & McCarthy, G. Intentional and unintentional medication non-adherence: a comprehensive framework for clinical research and practice? A discussion paper. *International journal of nursing studies*. 2007; 44(8), 1468-1477.

- [9] Hughes, CM. Medication non-adherence in the elderly. Drugs & aging. 2004; 21(12), 793-811.
- [10] Fernando, MLD., & Kazarian, SS. Patient education in the drug treatment of psychiatric disorders. CNS Drugs.1995; 3(4), 291-304.
- [11] Wise, J., & Operario, D. Use of electronic reminder devices to improve adherence to antiretroviral therapy: a systematic review. *AIDS patient care and STDs*. 2008; *22*(6):495-504.
- [12] Feder, JL. Cell-phone medicine brings care to patients in developing nations. *Health Affairs*. 2010; 29(2):259-263.
- [13] Patel, S., Jacobus-Kantor, L., Marshall, L., Ritchie, C., Kaplinski, M., Khurana, PS., & Katz, RJ. Mobilizing your medications: an automated medication reminder application for mobile phones and hypertension medication adherence in a high-risk urban population. *Journal of diabetes science and technology*. 2013; 7(3):630-639.
- [14] Shet, A., Arumugam, K., Rodrigues, R., Rajagopalan, N., Shubha, K., Raj, T. & De Costa, A. Designing a mobile phone-based intervention to promote adherence to antiretroviral therapy in South India. *AIDS* and Behavior. 2010; 14(3):716-720.
- [15] Vervloet, M., Linn, AJ., van Weert, JC., De Bakker, DH., Bouvy, ML., & Van Dijk, L. The effectiveness of interventions using electronic reminders to improve adherence to chronic medication: a systematic review of the literature. *Journal of the American Medical Informatics Association*. 2012; 19(5):696-704.
- [16] Huang, HL., Li, YCJ., Chou, YC., Hsieh, YW., Kuo, F., Tsai, WC. & Chuang, CJ. Effects of and satisfaction with short message service reminders for patient medication adherence: a randomized controlled study. *BioMed Central medical informatics and decision making*. 2013; 13(1):127.
- [17] Mall, S., Sibeko, G., Temmingh, H., Stein, DJ., Milligan, P., & Lund, C. Using a treatment partner and text messaging to improve adherence to psychotropic medication: a qualitative formative study of service users and caregivers in Cape Town, South Africa. *African journal of psychiatry*. 2013; *16*(5):364-370.
- [18] Keränen, T. & Liikkanen, S. Medication reminder service for mobile phones: an open feasibility study in patients with Parkinson's disease. *Telemedicine and e-Health*. 2013; 19(11):888-890.
- [19] Lei, X., Liu, Q., Wang, H., Tang, X., Li, L. & Wang, Y. Is the short messaging service feasible to improve adherence to tuberculosis care? A cross-sectional study. *Transactions of the Royal Society of Tropical Medicine and Hygiene. 2013; 107*(10):666-668.
- [20] Rodrigues, R., Shet, A., Antony, J., Sidney, K., Arumugam, K., Krishnamurthy, S. & DeCosta, A. Supporting adherence to antiretroviral therapy with mobile phone reminders: results from a cohort in South India. *Public Library of Science ONE*. 2012; 7(8):e40723.
- [21] Velthoven, MV., Brusamento, S., Majeed, A. & Car, J. Scope and effectiveness of mobile phone messaging for HIV/AIDS care: a systematic review. *Psychology, health & medicine*.2013;18(2):182-202.
- [22] Vervloet, M., van Dijk, L., Santen-Reestman, J., Van Vlijmen, B., Van Wingerden, P., Bouvy, ML. & de Bakker, DH. SMS reminders improve adherence to oral medication in type 2 diabetes patients who are real time electronically monitored. *International journal of medical informatics*. 2012; 81(9):594-604.
- [23] Da Costa, TM., Barbosa, BJP., Sigulem, D., de Fátima Marin, H. & Pisa, IT. Results of a randomized controlled trial to assess the effects of a mobile SMS-based intervention on treatment adherence in HIV/AIDS-infected Brazilian women and impressions and satisfaction with respect to incoming messages. *International journal of medical informatics*. 2012; 81(4):257-269.
- [24] Person, AK., Blain, ML., Jiang, H., Rasmussen, PW. & Stout, JE. Text messaging for enhancement of testing and treatment for tuberculosis, human immunodeficiency virus, and syphilis: a survey of attitudes toward cellular phones and healthcare. *Telemedicine and e-Health*. 2011; 17(3):189-195.
- [25] Strandbygaard, U., Thomsen, SF. & Backer, V. A daily SMS reminder increases adherence to asthma treatment: a three-month follow-up study. *Respiratory medicine*. 2010; 104(2):166-171.
- [26] Boland, MV., Chang, DS., Frazier, T., Plyler, R., Jefferys, JL. & Friedman, DS. Automated Telecommunication-Based Reminders and Adherence With Once-Daily Glaucoma Medication Dosing: The Automated Dosing Reminder Study. *Journal of the American Medical Association Ophthalmology*. 2014; 132(7):845-850.
- [27] Miloh, T. & Annunziato, R. Adhering to your non-adherent patients: the challenge of non-compliance. Acta Paediatrica. 2010; 99(3):335-337.
- [28] Miloh, T., Annunziato, R., Arnon, R., Warshaw, J., Parkar, S., Suchy, F. J. & Kerkar, N. Improved adherence and outcomes for pediatric liver transplant recipients by using text messaging. *Pediatrics*. 2009; 124(5):e844-e850.
- [29] Dowshen, N., Kuhns, LM., Gray, C., Lee, S. & Garofalo, R. Feasibility of interactive text message response (ITR) as a novel, real-time measure of adherence to antiretroviral therapy for HIV+ youth. *AIDS* and behaviour. 2013; 17(6):2237-2243.
- [30] de Jongh, T., Gurol-Urganci, I., Vodopivec-Jamsek, V., Car, J. & Atun, R. Mobile phone messaging for facilitating self-management of long-term illnesses. *The Cochrane Library*. 2012.
- [31] Pellowski, JA. & Kalichman, SC. Recent advances (2011-2012) in technology-delivered interventions for people living with HIV. *Current HIV/AIDS Reports*. 2012; 9(4):326-334.

- [32] Nglazi, MD., Bekker, LG., Wood, R., Hussey, GD. & Wiysonge, CS. Mobile phone text messaging for promoting adherence to anti-tuberculosis treatment: a systematic review. *BMC infectious diseases*. 2013; 13(1):566.
- [33] Laffer, MS., & Feldman, SR. Improving medication adherence through technology: analyzing the managing meds video challenge. *Skin Research and Technology*. 2014; 20(1):62-66.
- [34] Dayer, L., Heldenbrand, S., Anderson, P., Gubbins, PO. & Martin, BC. Smartphone medication adherence apps: potential benefits to patients and providers. *Journal of the American Pharmacists* Association. 2013; 53(2):172.
- [35] Wickham, B., Holbrook, R. & Dinh, K. Evaluation of a medicines list iPhone app. In *Health Informatics: Digital Health Service Delivery-The Future is Now! June, 2013; 188:142. IOS Press.*
- [36] Granger, BB., & Bosworth, H. Medication adherence: emerging use of technology. *Current opinion in cardiology*. 2011; 26(4):279.
- [37] Tran, N., Coffman, JM., Sumino, K. & Cabana, MD. Patient reminder systems and asthma medication adherence: a systematic review. *Journal of Asthma*. 2014; 51(5):536-543.
- [38] Stankovic, JA., Cao, Q., Doan, T., Fang, L., He, Z., Kiran, R. & Wood, A. Wireless sensor networks for in-home healthcare: Potential and challenges. *High confidence medical device software and systems* (HCMDSS) workshop. 2005; pp. 2-3.
- [39] Finkelstein, J., Wood, J. & Cross, R. Design and implementation of home automated telemanagement system for patients with ulcerative colitis. *eHealth, Telemedicine, and Social Medicine International Conference (ETELEMED).* 2009; pp. 220-226.
- [40] Reeder, B., Demiris, G. & Marek, KD. Older adults' satisfaction with a medication dispensing device in home care. *Informatics for Health and Social Care*. 2013; 38(3):211-222.
- [41] Wakefield, BJ., Orris, LJ., Holman, JE. & Russell, CL. User perceptions of in-home medication dispensing devices. *Journal of gerontological nursing*. 2008; 34(7):15-25.
- [42] Winland-Brown, JE. & Valiante, J. Effectiveness of different medication management approaches on elders' medication adherence. *Outcomes management for nursing practice*. 1999; 4(4):172-176.
- [43] Sather, BC., Forbes, JJ., Starck, DJ. & Rovers, JP. Effect of a personal automated dose-dispensing system on adherence: a case series. *Journal of the American Pharmacists Association*. 2006; 47(1):82-85.
- [44] Naditz, A. Medication compliance—helping patients through technology: Modern "smart" pillboxes keep memory-short patients on their medical regimen. *Telemedicine and e-Health*. 2008; 14(9):875-880.
- [45] Hersberger, KE., Boeni, F. & Arnet, I. Dose-dispensing service as an intervention to improve adherence to polymedication. *Expert review of clinical pharmacology*. 2013; 6(4):413-421.
- [46] Smith, GE., Lunde, AM., Hathaway, JC. & Vickers, KS. Telehealth home monitoring of solitary persons with mild dementia. *American journal of Alzheimer's disease and other dementias*. 2007; 22(1):20-26.
- [47] Kamimura, T., Ishiwata, R. & Inoue, T. Medication reminder device for the elderly patients with mild cognitive impairment. American journal of Alzheimer's disease and other dementias.2012;27(4):238-242.
- [48] Kamimura, T. & Ito, H. Glycemic control in a 79-year-old female with mild cognitive impairment using a medication reminder device: a case report. *International Psychogeriatrics Association*. 2014; 26(6):1045-1048.
- [49] Velligan, D., Mintz, J., Maples, N., Xueying, L., Gajewski, S., Carr, H. & Sierra, C. A randomized trial comparing in person and electronic interventions for improving adherence to oral medications in schizophrenia. *Schizophrenia bulletin*. 2013; 39(5):999-1007.
- [50] Haberer, JE., Robbins, GK., Ybarra, M., Monk, A., Ragland, K., Weiser, SD. & Bangsberg, DR. Realtime electronic adherence monitoring is feasible, comparable to unannounced pill counts, and acceptable. *AIDS and behaviour*.2012; 16(2):375-382.
- [51] De Bleser, L., De Geest, S., Vandenbroeck, S., Vanhaecke, J. & Dobbels, F. How accurate are electronic monitoring devices? A laboratory study testing two devices to measure medication adherence. *Sensors*. 2010; 10(3):1652-1660.
- [52] Christensen, A., Christrup, LL., Fabricius, PE., Chrostowska, M., Wronka, M., Narkiewicz, K. & Hansen, EH. The impact of an electronic monitoring and reminder device on patient compliance with antihypertensive therapy: a randomized controlled trial. *Journal of hypertension*. 2010; 28(1):194-200.
- [53] Christensen, A., Christrup, LL., Fabricius, PE., Chrostowska, M., Wronka, M., Narkiewicz, K. & Hansen, EH. Survey of patient and physician assessment of a compliance reminder device in the treatment of hypertension. *Blood pressure*. 2009; *18*(5): 280-285.
- [54] McKenney, JM., Munroe, WP. & Wright, JT. Impact of an electronic medication compliance aid on longterm blood pressure control. *The Journal of Clinical Pharmacology*. 1992; 32(3):277-283.
- [55] Checchi, KD., Huybrechts, KF., Avorn, J. & Kesselheim, AS. Electronic Medication Packaging Devices and Medication Adherence: A Systematic Review. *Journal of the American Medical Association*. 2014; 312(12):1237-1247.