

On the Use of Mobile-Based Notification Systems for Medication Adherence: A Systematic Review

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Abstract

Objective: The SMS and voice features are the most commonly documented uses of mobile technologies. This paper systematically reviews existing mobile notification systems for medication adherence, stating the strengths and limitations. **Methods:** Search was carried out on PubMed, EBSCO and Science Direct online databases. Studies including the use of both voice call and SMS features as notification systems were included. Twenty (20) full text citations were included in the review. The studies reported the various uses of voice-enabled and SMS features of the mobile phone technology and the mode in which the interventions were sent. **Findings:** The review highlighted the inadequacy in research incorporating notification systems and voice call feature of mobile technologies. **Applications:** The effectiveness of using this feature especially in rural areas characterized by high population of illiterates and people between the ages of 40 and above.

Keywords: Adherence, Medication, Mobile Technology, Notification System

1. Introduction

Presently, the widespread use of mobile technology in healthcare management with the affordable costs of mobile devices worldwide has led to an array of mobile phone based interventions¹. Mobile technology offers great improvement to the service level and reduces a great amount of cost in the health sector. The adoption of mobile technology also provides productivity gains through the interventions that are being introduced². The ubiquity of mobile phones is an assurance that an increasing amount of mobile health interventions will be provided. Mobile health (M-health) which sprung from mobile technology has advanced healthcare management with the incorporation of mobile devices into rendered healthcare services to enable easy accessibility. M-health interventions offer various support at a low cost, regardless of geographical location. The availability of mobile technology makes it useful for effective communication and interaction between health-workers and patients.

It also makes information acquisition easier and more convenient for both parties. There is no doubt that the conception of m-health has caused a significant improvement in the delivery of service in the health sector. Taking advantage of the features of mobile devices, applications that support healthcare management are being developed and built. M-health initiatives that have been adopted include health call centres, toll-free emergency, mobile telemedicine and appointment reminders³. Solutions to the problem of non-adherence and non-attendance of appointments are also being developed by incorporating the features of mobile phones into alert systems. Alert systems aim to remind patients of appointment reminders, drug regimens and to educate patients. Various systems that aim to serve as appointment and medication reminders already exist be it SMS-based, voice-based or both. Also various articles have been published reviewing the impact of these systems on healthcare management.

This systematic review is carried out to examine features of existing systems highlighting the successes and

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flaws of these systems. It is also done to assess the response of a population to these systems and the impact of the system on non-adherence. Findings on existing systems and literature will be reported and assessed.

2. Method

A systematic literature review was carried out to assess all English language articles between 2004 and 2016 that refer to mobile technologies and systems that aim at improving adherence of cancer patients to medication. Studies were identified by searching electronic databases, articles in Journals while existing systems were identified by searching for them electronically using key words like 'medical alert system' and 'mobile alert system'. The reporting of this paper follows the PRISMA (Preferred Reporting Items for Systematic Reviews and meta-analyses) guidelines. The review is aimed at identifying articles that discuss the design, development and evaluation of mobile alert systems in all sectors in general but more focused on the health sector. Hence it focuses on searching majorly medical journals: Pubmed/Medline, Science Direct, and General Journals: EBSCO

2.1 Inclusion Criteria

Articles that refer to mobile alert or notification systems for general healthcare management were included in the study. Both SMS based and voice based systems were considered provided they were incorporated into mobile phones. The system could be for either prescription adherence or appointment reminders with additional features. It must be doing one of both. The intervention and control groups had to be clearly defined in the study with the result derived from carrying out trials.

2.2 Exclusion Criteria

Articles were excluded if they were not in English and referred to alert systems that include wearable to detect body vitals and alert systems that are used for non-clinical purposes. Exploratory studies, literature reviews of existing systems and protocols were excluded as they do not have results from actual trials. Also, reminder systems that targeted only the health workers and not primarily the patients were excluded as they cannot be used to confirm the impact of a reminder system on the patient's adherence. Reminder systems that targeted both health-workers and patients were not excluded.

2.3 Information Sources

Information was obtained from EBSCO, Science Direct and PubMed digital databases with the following defined search terms: 'mobile alert system' OR 'notification system', OR 'alert system' OR 'adherence' OR 'compliance' OR 'voice based alert' OR 'voice based notification' OR 'telephone alert' OR 'Telephone based'. Other search terms include 'mobile technology' OR 'mobile health' OR 'm-health'.

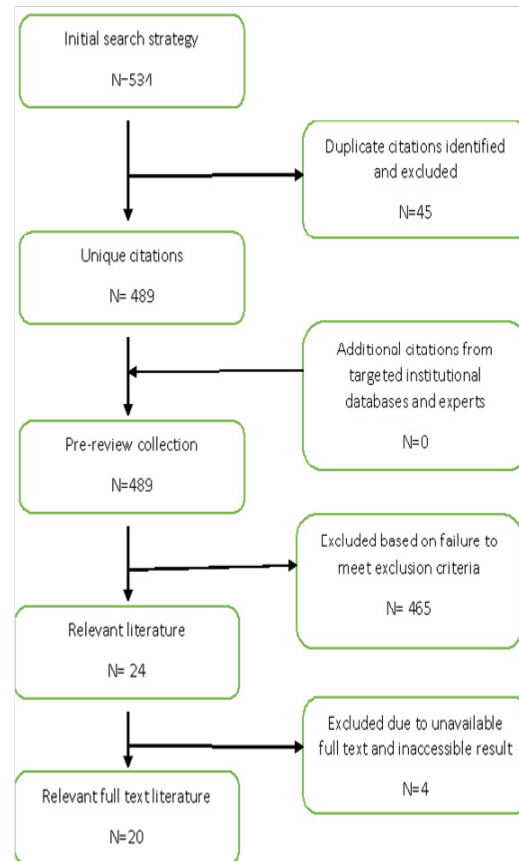


Figure 1. Search strategy.

2.4 Search and Study Election

Database searches were done with the defined search terms including additional key words like telephone and telephone alert system. The articles were first screened by their titles then by their abstracts to assess if they met the inclusion criteria. On meeting the inclusion criteria, their full texts were read fully and analysed so the findings could be recorded in this review. Articles that did not meet the criteria were excluded.

The initial search strategy yielded 534 publications. 45 duplicate citations across the various databases were

Table 1. Study characteristics of identified publications

Ref	Publication Title	M-tech intervention	Health Issue addressed	Purpose of M-tech	Country/Region
In ⁴	Mobile Technology for Improved Family Planning (MOTIF): the development of a mobile phone-based (M-health) intervention to support post-abortion family planning (PAFP) in Cambodia	Voice-based	Abortion	Remind clients about contraceptive methods, identify problems with side effects early, provide support relating to side effects	Asia/Cambodia
In ⁵	Improving attendance at post-emergency department follow-up via automated text message appointment reminders: a randomized controlled trial	Automated text message (SMS)		Appointment reminder	USA
In ⁶	A randomized controlled behavioural intervention trial to improve medication adherence in adult stroke patients with prescription tailored Short Messaging Service (SMS)-SMS4Stroke study	Text message (SMS)	Stroke	Improve medication adherence for stroke in	Pakistan
In ⁷	Improving treatment adherence for blood pressure lowering via mobile phone SMS-messages in South Africa: a qualitative evaluation of the SMS-text Adherence Support (StAR) trial	Text message (SMS)	Blood pressure	Improve adherence to treatment for lowering blood pressure and clinic visits	Africa/South Africa
In ⁸	Text Message Reminders for Second Dose of Influenza Vaccine: A Randomized Controlled Trial	Text message (SMS)	Influenza	Improve taking of 2 nd dosage of influenza vaccine	New York City
In ⁹	SMS reminders to improve the tuberculosis cure rate in developing countries (TB-SMS Cameroon): a protocol of a randomised control study	Daily SMS messages	Tuberculosis	Remind patients to take tuberculosis medication with standard directly observed Treatment shot strategy	Africa/Cameroon
In ¹⁰	Addressing medication nonadherence by mobile phone: Development and delivery of tailored messages	Tailored text messages	Diabetes	Improve medication adherence	
In ¹¹	M-health: Using Mobile Technology to Support Healthcare	Text message (SMS) and Voice-call	Chronic diseases	Improve adherence to medication by alerting and informing patients of risks of non-adherence	Nigeria
In ¹²	A text messaging intervention to promote medication adherence for patients with coronary heart disease: a randomized controlled trial	Text message (SMS)	Coronary heart disease	Medication reminders and education	

In ¹³	The Impact of Text Message Reminders on Adherence to Antimalarial Treatment in Northern Ghana: A Randomized Trial	Text message (SMS) Reminders	Malaria	Improve adherence to antimalarial treatment	Africa/ Ghana
In ¹	Effect of mobile telephone reminders on treatment outcome in HIV: evidence from a randomised controlled trial in India	Automated, Customized and interactive voice reminders and pictorial message	HIV	Increase adherence to therapy and decrease virological failure	India
In ¹⁴	Using no-cost mobile phone reminders to improve attendance for HIV test results: a pilot study in rural Swaziland	Voice- based (missed call/flashing)	HIV	Follow up reminder to collect blood test results of HIV tests.	Swaziland
In ¹⁵	The Effect of Automated Telephone Appointment Reminders on HIV Primary Care No-Shows by Veterans	Telephone	HIV	Appointment reminder	
In ¹⁶	Designing and Implementing an Innovative SMS-based alert system (RapidSMS-MCH) to monitor pregnancy and reduce maternal and child deaths in Rwanda	Text message (SMS) reminders	Pregnancy, maternal and child deaths	Monitor pregnancy and reduce maternal and child deaths	Rwanda
In ¹⁷	Mobile Telephone Short Message Service Reminders Can Reduce Nonattendance in Physical Therapy Outpatient Clinics: A Randomized Controlled Trial	Text message (SMS) reminders		Adherence to appointment in physical therapy clinics	
In ¹⁸	Text message reminders to promote human papillomavirus vaccination	Text message (SMS) Reminder	Human Papilloma Virus cervical cancer	Improve adherence to HPV2 and HPV3 vaccine	America
In ¹⁹	Design of a randomized trial to evaluate the influence of mobile phone reminders on adherence to first line antiretroviral treatment in South India - the HIVIND study protocol	Interactive voice and text messages	HIV	Improve adherence to antiretroviral treatment. Reminder to take ART	India
In ²⁰	The Effectiveness of Outpatient Appointment Reminder Systems in Reducing No-Show Rates	Automated telephone reminder	N/A	Remind patients of their scheduled appointments with physicians	
In ²¹	Mobile phone text messaging to promote healthy behaviours and weight loss maintenance: a feasibility study	Text messaging	Obesity	Motivate obese people to sustain healthy behaviours	America
In ²²	Use of SMS text messaging to improve outpatient attendance	Text message		Appointment reminders	

identified and excluded. The remaining 489 publications were screened and 464 were excluded for being literature reviews, exploratory studies or for referring to wearable alert systems, alert systems focused only on the health worker. They were also excluded based on the intervention being reviewed. 24 publications were selected for full-text reviews, 1 of which was excluded because its full-text was unavailable. 23 publications were selected for full-text screening. Upon full-text screening, 3 publications were removed as their interventions could not be assessed. The final 20 publications were used for this systematic literature review. The publications selected included trials carried out in various countries with a varying class of population. The flow chart in Figure 1 shows the search strategy.

2.5 Data Collection Process

The following data was collected from each article that met the inclusion criteria: Name of the first author, year of publication, the feature of the mobile technology used as a reminder/alert system; region the study is being done in, health issue being addressed and the purpose of the technology. Table 1 represents these collected characteristics. These data were collected to analyse particularly the feature of the mobile technology being employed whether voice-based, SMS-based or MMS-based so adequate comparison between the two can be done to discover their strengths and weaknesses. The intervention details were also collected with the control group and the results. The health issue addressed is important to know the most addressed issue and the least addressed issue.

Table 2. Effect of interventions on medication adherence

Ref	Sample size	Control Group	Intervention duration	Adherence summary/result
In ⁴	100 abortion clients		3-month	Increase in self-reported contraception use for four months post abortion
In ⁵	374 participants	Written follow up instruction	3 months	Adherence rate in the intervention group was 72.6% and 62.1% in the control group. There was an improvement in adherence rate
In ⁶	200 participants (Intervention group n=100 Control group n=100)	Patients received usual standard care consisting of regular follow up visits (100 participants).	2 months	Medication score in intervention group=7.4 while in control group is 6.7 with a baseline adherence level of 6.6
In ⁷	22 participants (16 females, 6 males)	Received non-health related messages	12 months	
In ⁸	Children (n=660) Written reminder only(n=219), conventional text message (n=225), educational text message (n=216)	Written reminder only (219 participants)	42 days	Embedding educational messages in reminder improved effectiveness of text message as this group had a higher increase in adherence than any group. Receipt of dosage was between 66.7% to 73.7% with text messages as again 51.7% with written reminders.
In ⁹	208 participants (intervention group n=104, control group n=104)	No SMS intervention with standard Directly Observed Treatment Short (DOTS) strategy. Welcome message at the beginning of intervention only (104 participants).	12 months	No conclusion
In ¹²	84 patients(Text message for medication reminder and educational message n=28, educational text message only n=28 and no text message=28)	Received no text messages (28 participants).	30 Days	Total adherence level increased over time and the number of dosages taken by the first group was higher than that of other groups

In ¹³	1110 participants (Control group n=538, reminder-only message(A)=572, reminder and additional information (B) =304)	Received generic malaria prevention message after 120 hours (538 participants)		Adherence rate in control group-61%, Message A group- 66.4% and Message B group- 64.1%. Reminder messages increase adherence level
In ¹	631 participants (Intervention n=315, control group n=316)	Standard care- 3 counselling sessions, routine clinical and laboratory tests and follow up every 6 months (316 participants).	96 weeks	An increase in adherence means a decrease in virological failure. Rate of virological failure in intervention group-10.52 and in control group=10.73
In ¹⁴	300 HIV patients	No control group	6 months before and 6 months after	No difference in attendance after implementing intervention.
In ¹⁵	584 participants (intervention group n=374, control group n=210)	Provider delivered verbal appointment, staff delivered appointment reminder card (210 participants)	6 months	After intervention there was a significant decrease in no-shows (non-attendance)
In ¹⁷	679 participants (SMS reminder n= 342, no reminder n=337)	No SMS reminder before next appointment (337 participants).		Non-attendance rate of control group was 16% while that of intervention group was 11%. There is a significant reduction in non-attendance rate.
In ¹⁹	600 patients (Intervention arm n=300, control arm n=300)	Routine standard care which includes counselling sessions, routine clinical and laboratory tests and follow up assessments (300 participants).	24 months	
In ²⁰	9,835 participants (Clinic staff reminder n=3266, automated appointment reminder n=3219 and no reminder n=3350)	Received no reminder at all (3350 participants)	3 months	Non-attendance rate of control group was 23.1% which is significantly higher when compared with 17.3% of automated reminder group.
In ²²	2864 participants	Historic control group who received no reminder.	2 months	Failure to attend rate decreased from 23% to 14.2% between August and September

Table 3. Intervention modes and research type

Ref	Research Type	Intervention Mode
In ⁴	Formative research	Automated voice messages to phones of participants for three months at the time of day of their preference. Messages are sent every two weeks. It allowed for feedback from patients.
In ⁵	Randomized control trial	Patients received automated, text message appointment reminders that contains date, time and clinic location at 7,3 and 1 day before scheduled visits. The message sent contains the patient's name.
In ⁶	Randomized controlled intervention trial	SMS messages containing personalized prescription tailored daily medication reminder with health information twice weekly
In ⁷	Randomized control trial	Semi-tailored SMS messages were sent to the patient in one of the three local languages (English, isiXhosa, Afrikaans). Feedback can be received from the participants.

In ⁸	Randomized control trial	Text message reminding patients of dosage date with educational information and ordinary reminder messages were sent to two different groups of patients.
In ⁹	Randomized control study	Participants received daily SMS in French or English. The messages will be changed every two weeks and encouraging messages will be added.
In ¹²	Randomized control trial	SMS text messages were sent to remind patients of their medications and also to educate patients.
In ¹³	Randomized trial	A simple reminder message and an additional educational message on reasons to complete anti malaria dosage
In ¹	Randomized controlled trial	Customized motivational voice call sent once a week at time selected by the patient with pictorial message.
In ¹⁴	Pilot Study (before and after operational research study design)	No difference Patient will be flashed/buzzed and a message like “go to hospital” will be displayed on his phone.
In ¹⁵	Quasi experimental design study	Patients received automated telephone appointment 2 weeks before their scheduled HIV clinic appointments and 3 days before appointment date in form of text message saying “you have a medical appointment” on a certain date. Reduced no shows by 41%
In ¹⁸	Site based intervention	Parents received 3 text message reminders per week to remind them of their children’s appointment. 16% increase
In ¹⁹	Randomized control trial	Automated interactive voice calls sent once a week by any time selected by the participant with a weekly pictorial text message. A particular group could receive more information via text message if indicated.
In ²⁰		Patients were sent automated standardized messages 3 days in advance to remind them of appointments
In ²¹		Personal text messages (suggested by users) that included tips on healthy living and physical activity and reminders to drink water were sent at least three times a week at times indicated by the user.
In ²²		SMS message that contains the hospital name, day, date and time of appointment with a number to call if non-attendance is unavoidable

3. Results

The 20 articles reviewed reported projects in developed nations like America and other developing nations like Africa and India. The countries reported on are shown in Table 1 which shows the study characteristics. A wide scope of health issues was tended to; most papers focused on HIV/AIDS and diabetes. Other health-related issues involved maternal and child health, unhealthy living and chronic diseases. The systems were mostly used for medication adherence and appointment reminders. Other uses developed include educational, informational and information extraction. Research shows that reminder systems have been more effective since they started being

integrated with the features of mobile technologies. These features include the SMS, voice call and MMS. Majority of the interventions are developed using the SMS feature (n = 16), then the Voice call feature (n = 3) and few, the MMS feature. Some of these interventions make use of both the SMS and voice call features while some use both the SMS and MMS features (n = 2). Table 2 presents the effects of the mobile interventions on medication adherence while Table 3 presents the various

3.1 Mobile Features

SMS reminder systems are more effective with a younger population as an older population would rather have voice call reminders²³. Evidently more research has been

carried out on SMS interventions as they are more popular than other features. A major advantage mentioned for using texts is its scalability⁸. Also, the literate population prefer SMS reminders to any other means as they believe the timing of a phone call could interfere with their daily activities. They are more cost effective and engage patients in direct communication. It is convenient for both health workers and patients. It requires less labour and little investment in IT infrastructure as it already exists. It has proven effective by increasing patient attendance in all the studies this feature is used in. To make it more effective, health and self-management tips are sent with reminders to engage the patient. Although its major weakness is late realization of patients not receiving messages due to incorrect data entry or other factors as there's no confirmation to the receipt of SMS except specified. Text message reminders are less likely to get lost when compared with mail and written reminders⁵.

The strength of a call is the direct communication it engages patients in. one can be assured of message receipt so far as the user picks up the phone. It is also possible to have 2-way calls where information can be easily extracted from the use. The major issue discovered about the voice-call feature is the cost involved in placing calls and the time in which calls are placed. This feature is still being employed because of its ability to send information quickly and receive feedback faster than any other feature. The underdeveloped population prefer calls as most of them are illiterates and can't read, the message is better passed across to them by calls. The research done by¹⁴ makes use of "flashing" (beeping) as a way to alert patients instead of actually calling them. Although there was no significant difference between the control group and intervention group, more work should be done on cutting down the costs involved with using the features of mobile technology. In¹, used repeated calls and pictorial messages as an alternative to missed calls.

3.2 Issues Addressed by Reminder Systems

According to the selected articles, the major issue reminder systems in healthcare focuses on addressing is non-adherence. As the major purpose for non-adherence is outright forgetfulness²². Non-adherence to medication has presented itself as a primary reason for worsening of diseases. It also shows that reminder systems are important in the healthcare sector not only for medication adherence but also for appointment reminders (n = 7), education on adherence (n = 5) and healthy living (n = 2) and for collecting information from patients.

A patient's failure to attend hospital appointments had an impact on the hospitals efficiency and effectiveness and also reduces the revenue made by the hospital hence many methods for reminding patients of their appointment schedules have been studied²². Forgetfulness and unawareness of appointment details has been identified as a major reason for failure to attend appointments. The reminder systems aim at addressing this issue of forgetfulness.

Also mobile phone reminders via text messaging are a way to inform patients of how to live healthy lifestyles and avoid a variety of health problems. Embedding health literacy information into text message reminders makes it more effective⁸. Vaccines that require more than one dosage usually have their second dosages ignored by patients after taking the first, notifying them of the consequences of not completing their dosages is important. Unawareness of the consequences of missing appointments where information on various health tips would be given by the health worker is addressed by reminder systems as it aims to also educate patients. Reminder systems that educate and alert are more effective than those that primarily alert alone. Taking advantage of an opportunity to communicate with patients, reminder systems have also been used to inform patients on the advantages of taking certain vaccines and eating certain meals to maintain a healthy lifestyle. The popularity of mobile phones is independent on the poverty and literacy levels of the population group as almost anybody can afford a mobile phone. It therefore breaks the geographical barrier that exists between the hospital and the patient.

Appointment reminders were not effective with homeless patients and patients with mental health disorders¹⁵. Results also show that it is ineffective among patients who use illicit drugs or members of racial and ethnic minorities. Regardless of the diseases or healthcare challenge addressed, as long as it requires consistency in some way, a mobile reminder system in most cases is useful and effective. Most of the diseases addressed are chronic diseases as they require consistent self-management. Reminder systems can be embedded in various platforms but receiving the reminders via a mobile phone is efficient in alerting patients.

3.3 Discussion

This review shows that more research is being carried out on reminder systems and more ways to make it effective is being discovered. The findings of this review indicate that reminder systems are integrated using M-health

technologies and as more of these evolve, better systems will evolve. The ubiquity of mobile technology accounts for its growing popularity level. A reminder system hence attempts to prompt people of these things so they can remember regardless of the business of the day. According to research such a system would have to be integrated in the everyday life of a regular person to be effective by using a mobile technology that can be easily accessed. Reminder systems improved medication adherence and attendance to appointments. The patient population that might benefit from this reminder system is the 24 to 60 year old age group. Research shows they are more effectively alerted by voice calls as they might actually forget to read text messages. This technology hasn't been focused on in the past years hence the findings on it are limited compared to that of text messages.

In some cases, reminder systems cause significant changes to adherence while in other cases, it makes no difference. Embedding educational messages to adherence messages is a more effective means. Reminder messages alone have less impact than embedding reminder messages with health tips, educational messages or general information. A research done in India for increasing adherence level of AVR was unable to detect a significant effect of voice reminders on adherence as the intervention included reminders only. The complexity level and nature of mobile phone communication has an effect on how efficient it could be¹.

The content of reminders affects the response of the patient after a short period of time. Some reminders become boring and redundant, predictable and easy to ignore by the patients. There should be a variety of messages to be sent to the patients per time. Patients responded better to personalized and tailored messages as it resembled a direct interaction with the health workers. The effect of the reminders can be dependent on the literacy level and level of development of the country setting.

4. Conclusion

The most common reason discovered for non-adherence remains forgetfulness; mobile health is evolving and mobile device reminders seem to be the most promising solution to increasing adherence rate. The research carried out on the voice call feature is limited as this intervention is not commonly used across the healthcare sector for alerts. More work should be carried out on effectively making use of the voice call feature as a reminder sys-

tem as it may be more effective than text messaging. The research presently done on it shows that it is effective in alerting a larger percentage of the population has a future in the health sector. The voice feature should be utilized more. In the long run, mobile phone reminders alone have less impact on patients when compared with those embedded with additional support messages. This review was limited by access to database and the scope of the study which included articles in English collected through scholarly and organizational databases. There was limited access to the databases. Many M-health projects on reminder systems may not have actually been reported.

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