A framework for mobile healthcare answers to chronically ill outpatient non-adherence

Mihail Cocosila PhD
Student

Norm Archer PhD
Professor Emeritus

DeGroote School of Business, McMaster University, Hamilton, Ontario, Canada

Introduction

Today’s society is seeing a global contradiction between patient demands for better quality of health care and the ability of the system to meet their expectations.1 This is the background for the pressures from chronic diseases and conditions that, combined, represented 54% of the burden (that is, lost years of healthy life) of all illnesses worldwide in 2001, and will exceed 65% in 2020, according to the World Health Organization.2

One possible answer to the above challenges is for increased patient-centred long-term care in out-of-hospital conditions (both in primary care and in home care programmes encompassed in this paper under the term of ‘outpatient’ programmes) with patients taking a proactive role.3 Numerous studies have shown self-management to be effective for chronic conditions in terms of patient and societal results. For instance, a controlled study of 191 patients with chronic obstructive pulmonary disease (COPD) reported improved health status and reduced hospital utilisation for patients that followed a disease-specific self-management programme.4 A two-year asthma self-management study reported the same positive results, in addition to increased satisfaction with healthcare for the 110 individuals successfully completing the programme.5 Although this type of integrated approach is highly beneficial for both patients and the healthcare system, patient adherence (also known as ‘compliance’) to the prescribed treatment requirements (that research has shown to be no more

ABSTRACT

Non-adherence (also known as ‘non-compliance’) is a major barrier undermining healing efforts within out-of-hospital self-management programmes, resulting in waste of human and social resources. This study suggests a theoretical framework of activities through which mobile patient solutions might address non-adherence determinants in a broader context of clinical interventions. The goal of the paper is to explore a dilemma associated with such interventions: the uncertainty regarding the level of patient involvement and technology support. We follow a critical orientation approach in discussing this multi-faceted conundrum: we summarise the latest vision on adherence factors, we suggest several types of interventions through which mobile healthcare solutions could address them, and we explore in detail the dilemma of patient and technology roles. We conclude that there is no universally optimal solution, and practical conditions depending on patient, disease, treatment and healthcare system are determining factors in prescribing the level of patient involvement and technology support.

Our work is intended to stimulate further research into the nature of mobile solutions in healthcare and, especially, into patient acceptance aspects, in an endeavour to contribute to improving adherence with minimum obtrusiveness.

Keywords: adherence, chronic illness, compliance, information technology, mobile health care
than 50% on average) is a serious threat to the whole paradigm.\textsuperscript{2}

The problems of outpatient adherence on one hand, and the remarkable development of mobile information and communications in recent years on the other, led to the idea of an innovative approach for chronically ill outpatients: improving adherence with the use of mobile and wireless information technology (IT). This approach relies on one of the fundamental advantages of mobile commerce: the ability to reach individuals beyond a fixed location.\textsuperscript{6} Thus a one-to-one dialogue between the healthcare system/providers and remote patients becomes feasible. This fulfils the desideratum of tailoring and creating ‘segments of one’ for individual patients that is required by modern client-focused health management.\textsuperscript{7} It is nonetheless important to note that, no matter how helpful the technology might be, it should not substitute for but facilitate interactions between healthcare providers and patients. This can be decisive for the success of care activities because of the uniqueness of patients, diseases, comorbidities and treatments. However, besides the expected positive outcomes from using mobile IT to get closer to people, there are questions regarding possible obstacles and dilemmas, one of these being the ideal combination of patient and technology support. Previous research in this field has not established the appropriate proportion of self-management activities to be assigned to the two counterparts (that is, chronically ill people and mobile technology) to help outpatients improve their adherence to prescribed treatment. Exploring this research topic is essential in order to understand the suitability of mobile IT for outpatient interventions. Other undoubtedly important aspects of a comprehensive analysis (for instance, constraints of technical standards and existing wired technology already in place, data security and privacy, cost/benefit analysis, resistance to change, and training of patient and healthcare personnel) are beyond the scope of this work. Patient and healthcare personnel training on the advantages and also the limitations of mobile IT interventions (especially when exceptional conditions could occur) is a very important ingredient for success; however, it too is beyond the scope of this paper.

This paper suggests a theoretical framework of six ways to improve chronically ill outpatient adherence through mobile technology solutions within integrated clinical interventions, and discusses two key foreseen dilemmas: the balance between patient action and technology action on one side and mobile device-based technology and central server-based technology on the other. The next section explores how mobile IT could address outpatient adherence problems. The following section describes the two extremes for each of the two dilemmas: participative/non-participative patient and device/server-based technology. Finally, conclusions and some possible issues for future research are presented.

Can mobile information technology improve adherence?

This section explores how mobile technology could help in improving chronic outpatient adherence. We briefly present the determinants of adherence and why mobile IT solutions would be suitable for addressing some non-adherence problems. We present six ways through which mobile IT solutions that are carefully embedded in systematic clinical interventions might help chronically ill outpatients to achieve the necessary behavioural changes to improve their adherence to medical treatment.

Patient adherence: significance and factors

There is no general agreement in the literature on the causes of adherence and non-adherence. However, there is unanimity in showing that adherence is a complex phenomenon generated by a multitude of factors. A primary classification divides them into patient-related and external influences.\textsuperscript{2,8} Patient-related factors arise from inner psychology and attitudes and are under the individual’s control. They have the most significant impact on adherence but also mediate other categories of factors.

External influences are the traits of the patient or of the environment not under the patient’s control. They are related to the individual’s sociodemographic and economic traits (such as race, age, gender, socioeconomic status, job or family situation), health condition (for example, symptoms, disabilities and progression of illness), therapy offered (for example, form of medication and treatment, and duration), healthcare team (skills, workloads and reimbursement) and system (medication distribution, social attitudes and government regulation).

Since the above factors are closely related, interventions for improving outpatient adherence must include a carefully designed complex of several responses, acting simultaneously over a long period of time in order to achieve persistent and positive results.

Why use mobile IT?

In addition to clinical interventions targeting the pivotal barriers of patient health beliefs and patient–
physician collaboration, IT in general and mobile solutions in particular could address some objective problems of today’s home care that might hamper the healing process:

- lack of timely information about patient self-administered test results
- missing or late information related to patients filling prescriptions and actually taking their medications
- untimely connection with the healthcare system for counselling, feedback, support and rapid-response interventions
- lack of support and encouragement from the community and peers in similar health situations
- insufficient information about the disease and treatment.

Since ‘current methods of improving adherence for chronic health problems are mostly complex and not very effective’, and since today’s care model has the drawbacks described above, it is justifiable to examine solutions to some of these problems by an IT approach. Related to this, we suggest an innovative use of mobile IT to match the recognised features of mobile solutions to some non-intentional adherence problems: access (‘any time anywhere’ with the patient), quality (allows better communication channels with the healthcare system and community/support groups) and value (helps patients improve adherence with beneficial consequences for individuals and society).

Possible mobile IT interventions to improve outpatient adherence

Adherence is usually compromised by several elements working concurrently, and single-factor interventions are not productive. Therefore, for maximal effectiveness and efficiency, mobile interventions should be encompassed in more complex clinical models that would adopt a patient-centred perspective and involve specific elements depending on the patient, treatment, disease and the healthcare system. Box 1 summarises the benefits of the interventions that mobile solutions can provide in improving patient adherence, discussed in more detail below.

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Adherence factors involved</th>
<th>Possible benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring</td>
<td>Patient-related, Condition-related, Therapy-related</td>
<td>• Diminishing forgetfulness, stress and anxieties • Improving motivation, knowledge and skills in managing the treatment and disease in general</td>
</tr>
<tr>
<td>Reminding</td>
<td>Patient-related, Condition-related, Therapy-related</td>
<td>• Reducing forgetfulness and treatment stress and anxieties • Controlling aggravating factors • Increasing optimistic attitude, self-confidence and motivation</td>
</tr>
<tr>
<td>Consulting</td>
<td>Patient-related, Condition-related, Therapy-related, Healthcare team and system-related</td>
<td>• Reducing the effects of stress, anxieties • Diminishing consequences of insufficient knowledge or skills • Improving self-confidence and optimistic attitude</td>
</tr>
<tr>
<td>Supporting</td>
<td>Patient-related, Social and economic interventions</td>
<td>• Diminishing the feeling of isolation • Providing encouragement • Improving self-confidence</td>
</tr>
<tr>
<td>Informing</td>
<td>Patient-related, Social and economic interventions</td>
<td>• Improving patient knowledge • Fighting patient anxieties, misunderstanding and negative beliefs</td>
</tr>
<tr>
<td>Educating</td>
<td>Patient-related, Social and economic interventions</td>
<td>• Improving adherence following persistent and personalised application of the other interventions</td>
</tr>
</tbody>
</table>
Monitoring: Provides tighter control and management of the disease by patient self-testing, measuring and recording results so as to track their variation in time.\textsuperscript{13} Compared with wired solutions (such as landline telephone or web), mobile monitoring offers better flexibility and convenience by being always available to the patient.

Reminding: Refers to notifying patients about taking specific medication, performing self-tests and measurements, refilling prescriptions, following a certain diet or exercising, coming to a consultation and, in certain situations, receiving feedback from the healthcare system about complying.\textsuperscript{14} Mobile solutions offer excellent opportunities for reminding because they are always with the user and allow real-time exchange of information in a personalised and unobtrusive manner (for example, voice, text and tactile vibrations).

Consulting: Good relationships and communications between patient and the healthcare providers are essential for adherence because successful patient self-management does not mean eliminating physicians from the picture. On the contrary, beyond the traditional thinking that stresses a doctor’s more ‘mechanistic’ traits like science and skill, recent reports acknowledge the predominance of more ‘nebulous factors like aggressiveness and consist-ency and ingenuity’\textsuperscript{15} for a doctor’s results. Therefore the ‘human’ side of medical care must be a \textit{sine qua non} ingredient of IT-assisted self-management. Compared with other channels of communication, mobile solutions allowing synchronous (such as phone-type), asynchronous (for instance, text messaging or email) or mediated (through automated software performing basic routine tasks) transmissions (including voice–text conversion and multimedia) are pervasive and more flexible.\textsuperscript{16}

Supporting: Although today’s patients are much more educated and informed about their health problems, they still need human interaction, support and counselling from peers and other members of the community.\textsuperscript{17} As mobile communications continue to grow in reach and capability, they might help support adherence interventions with the same efficacy that web support groups have demonstrated but with the additional advantages of flexibility and convenience (for example, multimedia messaging services allowing image transmission and dialogue with the wired web).\textsuperscript{18}

Informing: Common mobile devices like cell phones have limited ability to offer information because of the restrictions of the user interface. However, they could be timelier in informing about volatile sources of information, thus directing patients to valuable news in other media (such as TV and radio broadcasts, newspapers or websites).

Educating: According to Bodenheimer \textit{et al}, self-management education and collaborative care are the two equally significant sides of the patient–physician partnership paradigm that are currently emerging in chronic disease care.\textsuperscript{19} Self-management education must be present in adherence interventions since it has been proven to be effective in improving chronically ill patient clinical outcomes.\textsuperscript{19} However, since education is a complex and lengthy process, it is difficult for mobile solutions (as for other types of online solutions such as web-based education) to address it adequately. A better education could be acquired through the constant application of other mobile interventions we have discussed, stimulating a combination of productive information and action for the patient.

It must also be stressed that it would be unrealistic to expect wireless and mobile devices successfully to address the profound causes of intentional non-adherence related to patient factors. Nothing can succeed when it is against the patient’s will or when an individual is dissatisfied with the healthcare system, provider or treatment. However, all of the proposed mobile IT interventions would likely target some important sources of unwilling non-adherence such as forgetfulness, testing stress and anxieties, as well as the lack of knowledge and skills in applying the treatment, and self-managing the disease in general. Appropriate feedback and encouragement facilitated by wireless devices could foster optimistic attitudes, self-confidence and motivation, especially if an alerting feature is included.\textsuperscript{13}

The dilemma of patient and technology roles

In contrast to consulting, supporting and informing, which all involve unequivocal human activities, mobile monitoring and reminding interventions raise two potentially extreme approaches regarding the patient’s degree of involvement: total participation or no participation. Both ideas have advantages and disadvantages. They are analysed in detail below and summarised in Box 2.

Participative patient in monitoring and reminding

Monitoring of outpatient conditions is usually managed by the patient, but in some special situations (for example, lack of knowledge or skills, stage of the
illness or age) by other people like family or home care nurses. Having the patient perform the tests and record the results offers the advantage of developing the sense of activeness, consciousness and involvement that are essential for the success of self-management. Doing testing and tracking some health parameters by longitudinal comparison with previous outcomes, analysing and making decisions on the steps to follow would tend to make the patient more optimistic and responsible.\textsuperscript{13} This would also agree with a programme of patient empowerment (or collaborative care) that encourages people to participate in decisions on the health care they receive.\textsuperscript{19} However, the application of the empowerment paradigm for chronic illness is a complex issue.\textsuperscript{20} Since each patient is unique, physicians would expect to work individually with patients, and allow them to participate actively in decisions affecting their health.

The same situation applies when a patient records electronically the information about complying with a treatment activity they were reminded about (such as taking medication, performing a glucose test, and so on). The patient could enter compliance information through a voice recording or by pressing a few keys on the mobile device. Positive patient attitudes could be further reinforced if the patient received rapid feedback on their self-testing or drug taking activities.

The main disadvantage of the participative patient approach is the danger of requiring the patient to perform too many routine tasks, thus discouraging the individual. This can lead to a ricochet effect that could reduce adherence and threaten the entire disease self-management process.

### Box 2 Patient and technology: extreme types in mobile monitoring and reminding

<table>
<thead>
<tr>
<th>Patient</th>
<th>Non-participative</th>
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<tbody>
<tr>
<td>Consciousness of the programme</td>
<td>Saves time</td>
</tr>
<tr>
<td>Responsiveness</td>
<td>More reliable</td>
</tr>
<tr>
<td>Optimistic attitude</td>
<td>Less stressful</td>
</tr>
<tr>
<td>Self-management</td>
<td>Independent of knowledge and skills</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technology</th>
<th>Server-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Save air time</td>
<td>Timely informing of medical systems</td>
</tr>
<tr>
<td>Increase privacy</td>
<td>Better feedback</td>
</tr>
<tr>
<td>Less obtrusive</td>
<td>Higher persistence</td>
</tr>
<tr>
<td>Higher communication reliability</td>
<td>Timely undertaking of corrective efforts</td>
</tr>
<tr>
<td></td>
<td>Better collaboration with other adherence-improving efforts: consulting, supporting and educating</td>
</tr>
</tbody>
</table>

### Non-participative patient

The non-participative approach would eliminate almost totally any patient efforts in complying with disease monitoring and treatment, in order to reduce intrusion into their activities. In this case, automated mobile tools would perform tests, store time-stamped results and communicate them wirelessly to a remote monitoring centre. This could be an advantage for active patients trying to live a normal life by going to school, work or performing various activities without being disturbed by disease management activities. This could benefit the patient’s physical and mental state, treatment adherence and healing process in general.

Doing specific tests on a prescribed schedule without direct patient participation would also have the advantage of diminishing test stress and increasing test accuracy. Reminding patients to take a certain medication could also be partially automated through a ‘smart’ pillbox that would record or send information automatically when the pillbox was opened for taking medication.

The danger of non-participation is that patients would tend to become automated machines, not aware of what is happening in the healing process, thus negatively affecting the behavioural side of treatment adherence. The participation and education aspects of the chronic illness self-management process also would be weakened. Even feedback from the healthcare system and support from peers and social groups would have less effect for patients less aware of their state of health and its treatment.
As well as the direct patient-related dilemma regarding the patient’s role in mobile remote monitoring and reminding, there is also a technology conundrum: what would be the exact balance between the capabilities implanted in the mobile device and under the control of the patient, and those existing in a remote server managed by home care services, in order to maximise treatment outcomes and efficiency. Two extreme options are possible: storing the data in a mobile device (such as a personal digital assistant or smart cellphone) or communicating wirelessly with a central server. Both approaches would allow the patient to retrieve previous results for comparison purposes, as well as to receive feedback and reminders. However, in the general context of adherence interventions, some sensitive aspects separate the two options. These issues are described in the discussion below, and summarised in Box 2.

Device-based technology

Empowering the device with capabilities for storing various self-test results and confirmation of drug taking, as well as for giving the patient feedback and reminders, has real advantages in terms of economy. Thus remote monitoring and reminding interventions would not overwhelm a wireless channel with routine messages when the patient state is within acceptable limits and nothing abnormal occurs.

This device-based approach has the supplementary advantage of patient privacy. In normal situations, the patient is exchanging data only with the personal device, thus avoiding possible unauthorised tampering with confidential health information. Moreover, patient dialogue with applications stored on the mobile device is limited only by the reliability of the device and is not influenced by the temporary loss of connectivity that is not uncommon for wireless communications. However, there is a danger of loss of data if the device is stolen or mislaid, and the possibility of privacy violations through such losses. Modern technology access filters offer generic solutions for reducing potential patient data loss (for instance, the use of biometric identifiers) that could address privacy problems while avoiding long-term data storage on the mobile device.

Server-based technology

The opposite of storage of data pertaining to monitoring and reminding and providing appropriate feedback on a local device is use of a server-based implementation. This would require patients to use a basic wireless device, such as a cellphone or even a two-way pager, to send and receive data to/from a central server administered by the outpatient’s healthcare organisation in charge of the disease management programme.

This approach would offer the advantage of better monitoring of patient health conditions. All patient data would be immediately available to the healthcare organisation, so abnormal situations would be detected promptly. The organisation would be able to offer automated or fast, high-quality, human feedback (appropriate encouragement and/or criticism) that has been proven to be beneficial in improving patient adherence. Medical professionals could also contact patients when indicated by data observation, for instance for repeating certain self-tests or for asking about possible symptoms or side-effects, and even for recommending corrective action. This would add a consultation role to the monitoring/reminding interventions, with beneficial effects for adherence. The combination of all the above interventions could significantly improve outcomes and adherence in terms of both patient education and self-education.

Storing data centrally in real time would also offer better possibilities for personalising dialogue with the patient in order to make it more productive; for example, use of more feasible and reliable text-to-voice or voice-to-text conversion systems, or customised messages to suit patient preferences. Except for lower communication reliability, centralisation of data offers clear possibilities for longer time persistence; for example, eliminate the risk of accidental or intentional data erasure, of device failure, theft or loss, or of unwanted access to data by other individuals. Another advantage of this approach is the possibility of integration with other patient information systems already in place.

In conclusion, extreme views regarding active patient participation and non-participation, as compared to device-based and server-based technology, describe four possible situations as shown in Figure 1. More intermediate situations as a result of blending the extreme views are possible and likely in practice, but it is difficult to say which is the ‘best’ absolute approach. The design that should be adopted depends on several factors: patient, disease, condition and treatment specifics on one side, and the support possibilities of the healthcare system on the other. The target should always be increased patient adherence and minimal obtrusiveness for patients and healthcare professionals, while maximising the overall effectiveness of adherence interventions.
Conclusions

Poor adherence is a major source of concern for patients, medical professionals, healthcare systems and society in a world where health care is facing numerous challenges. Mobile solutions might help by improving adherence in an innovative manner but having the technology closer to the patient could either assist or interfere with improvements to patient support. One problem with finding an optimal answer is the patient–technology partition dilemma: the best combination would depend on a complex of factors relative to patient, disease, treatment and healthcare system possibilities.

Future research should examine, through a theoretical lens on technology acceptance, what combination of patient activity and mobile solution action would work best towards improving patient adherence with minimal obtrusiveness. Such research should also take into account possible negative human reaction to mobile solutions in this sensitive field, as well as the changes required to the current healthcare system and the related infrastructure required for supporting outpatients.

Despite the uncertainty and obstacles we have mentioned, further research into improving outpatient adherence with mobile IT solutions is worthwhile since ‘increasing the effectiveness of adherence interventions may have a far greater impact on the health of the population than any improvement in specific medical treatments’.

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ADDRESS FOR CORRESPONDENCE
Mihail Cocosila
DeGroote School of Business
McMaster University
1280 Main St W
Hamilton
Ontario L8S 4M4
Canada
Tel: +1 905-525-9140, ext. 26173
Fax: +1 905-521-8995
Email: cocosim@mcmaster.ca

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