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MOBILE HEALTHCARE ANSWERS TO CHRONICALLY ILL
OUTPATIENT NON-ADHERENCE: PATIENT PARTICIPATION AND
TECHNOLOGY CONUNDRUM

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ABSTRACT

Objectives: Non-adherence is a major barrier undermining all healing efforts within outpatient programs, resulting in waste of human and social resources. Innovative approaches that could be helpful in combating non-adherence would be based on the latest mobile healthcare technologies, integrated within a carefully planned approach. This study analyzes the factors generating chronically ill outpatient non-adherence and proposes concrete actions through which mobile solutions may address these determinants in a broader context of clinical interventions. The goal of the paper is to explore one of the main dilemmas associated with mobile healthcare interventions: the uncertainty regarding the level of patient involvement and of technology support. Methods: We follow a critical orientation approach in discussing this multifaceted conundrum. We begin by summarizing the latest vision on adherence factors. We then propose six types of interventions through which mobile healthcare solutions could address them. Finally we outline obstacles of m-healthcare solutions in adherence and explore in detail the pivotal dilemma of patient and technology roles. Results: 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 of technology support. Conclusions: The possible use of mobile healthcare technologies to address outpatient non-adherence would face uncertainties among which the conundrum of patient and technology participation. This work is intended to stimulate further research into the nature of mobile solutions in healthcare, in an endeavour to contribute to improving adherence with minimum patient obtrusiveness.

KEYWORDS

chronic illness, adherence, compliance, information technology, mobile healthcare

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1. INTRODUCTION

Modern patients are more mobile and active as well as better informed and technically savvier than ever. Accordingly, they expect health services to provide the same level of efficiency and technology support as other areas of contemporary society, such as e-commerce or e-banking. This presents a serious challenge for the health care system [1, 2].

Ageing is a supplementary concern today. The so-called "baby boomers" are now beyond full maturity and the ratio between working people and non-working pensioners in the developed world will drop from 3 to 1 in 1999 to 1.5 to 1 by 2030 [3]. This will further worsen the already noticeable shortage of hospital beds and healthcare personnel, due to lack of resources [4]. All in all, today's society is seeing a global contradiction between patient demands for better quality of healthcare and the ability of the healthcare system to meet their expectations [2].

This worrying picture is the background for the pressures from chronic diseases and conditions that combined represented 54% of the burden (i.e. lost years of healthy life) of all illnesses worldwide in 2001 and will exceed 65% in 2020 [5]. This situation has serious consequences not only for individuals but also for healthcare and society in general. For instance, diabetes is one of the most serious cost generators in healthcare: about $9 billion per year in Canada and $98 billion per year in the U.S. are spent for direct treatment and dealing with social consequences (e.g. absenteeism, decreased worker productivity, disability, and social problems) [6].

Consequently, the healthcare system is under great strain to provide better care at lower costs for chronically ill patients. One possible answer is for increased patient-centered long-term care in out-of-hospital conditions [7, 8]. Although this integrated approach is highly beneficial for both patients and the healthcare system, patient adherence to the prescribed treatment requirements is a serious threat to the whole paradigm. Many studies have shown that adherence is around 50% on average [5], and this hampers the whole healing process, since nothing can be done without conscious involvement of patients.

The above-described problems of outpatient adherence on one hand, and the remarkable development of mobile information and communications in recent years on the other hand, lead to the idea of an innovative approach for chronically ill outpatients: improving adherence with the use of mobile and wireless information technology [9]. This approach can be a fundamental support for the home telemedicine-based paradigm [10] that may offer patients better quality of life and improved health management conditions while avoiding the high costs of traditional acute care [1]. Mobile healthcare solutions have the potential to improve patient adherence by various interventions. However, besides the expected positive outcomes there are some questions regarding possible obstacles and dilemmas among the ideal combination of patient and technology activities.

This paper proposes six concrete actions to improve chronically ill outpatient adherence through mobile technology solutions within integrated clinical interventions, and discusses the balance between patient action and technology action on one side and mobile device-based technology and central server-based technology on the other side. Section 2 outlines

the concept of outpatient adherence, its roles, and the determining influence factors. Section 3 explores how mobile information technology could improve outpatient adherence, by defining and explaining six concrete interventions and outlining possible barriers. Section 4 briefly discusses possible obstacles and elaborates on two dilemmas influencing the efficiency of the proposed interventions: the proportion of patient and technology activity on one hand, and the proportion of device-based and server-based intervention on the other hand. Finally, conclusions and some possible issues for future research are presented in Section 5.

2.   OUTPATIENT ADHERENCE IN CHRONIC ILLNESSES: ROLES AND FACTORS

The combined effect of technological advances and patient expectations leads to the concept of the "impatient patient" who is better educated and informed in many fields including health, is becoming increasingly dissatisfied with the inefficiency of health services, and is feeling more solitary and helpless in a world that is promoting individualism [3]. The problem is further exacerbated for chronically ill outpatients that may require long term special multidisciplinary treatment [5].

Any model of action healthcare offered to combat the current proliferation of chronic disease and conditions gravitates around 'patient-centeredness' based on outpatient self-management. Research has shown that self-management leads to positive outcomes for outpatients with various chronic illnesses and conditions with high incidence and significant medical and social costs such as diabetes, asthma, depression, and hypertension [11]. However self-management cannot exist without patient involvement, proactive attitude, and adherence to the process [8]. Accordingly, it is increasingly being acknowledged that a change is occurring in accepted health care philosophy since "governments are now accepting that patients should have a say in what is provided" [12].

2.1   Patient adherence: significance and roles

Since undertaking a curing process involves accepting and following a medical treatment (e.g. seeking medical consultations and follow-ups, filling prescriptions, and taking medication), and changing a behaviour (e.g. following hygiene rules, undertaking a healthy diet, and an active life style), a comprehensive definition of adherence is "the extent to which a person's behaviour – taking medication, following a diet, and/or executing lifestyle changes, corresponds with agreed recommendations from a health care provider" as formulated in a study by the *World Health Organization* [5].

Adherence is considered a more appropriate term than the still very popular "compliance" because the latter suggests an unequal relationship between healthcare personnel (who would be professionally dominant) and the patient (who would be only a passive recipient of advice and suggestions). Moreover, the negative variant, "non-compliance", suggests almost a symptom of the disease under treatment, or even the disease itself [13]. Modern research is categorical in showing that the conception of the patient's role and adherence to treatment could not exist without a partnership between healthcare professional and patient [14, p.3] that is based on a negotiation model developing and fostering patient participation [15, 16].

In order to stress even further this collaboration, some studies use the term "concordance" instead of "adherence" [17].

Adherence is vital in the treatment of chronic illnesses, as more generally for any healing process, since in its absence negative outcomes occur for all the major actors involved in the treatment process: patient, healthcare professionals, and the healthcare system. Chronically ill non-adherent patients risk complications (even life-threatening in some cases) associated with the disease that may lead to hospitalization, absenteeism, and psychosocial problems [18]. Healthcare professionals obviously see their time and work efforts wasted by non-adherent patients. In a more profound way, the lack of adherence affects their professional beliefs, expectations, and skills in the relationship with patients [13]. For the healthcare system and society in general, it is clear that non-adherence causes a diversion of human and financial resources from patients who most need them to patients who, as a result of non-adherence, require supplementary services (e.g. consultations, lab tests, or medication) [18]. Non-adherence is the cause of "a veritable epidemic" that accounts for 6% of hospitalizations in the U.S. alone [19].

2.2   Factors influencing adherence

There is no general agreement in the literature on the causes of adherence and, respectively, 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 [9]. Patient-related factors are all the elements particular to the patient and under his/her control whereas external influences are the traits of the patient or of his/her environment not under the patient's control (Figure 1).
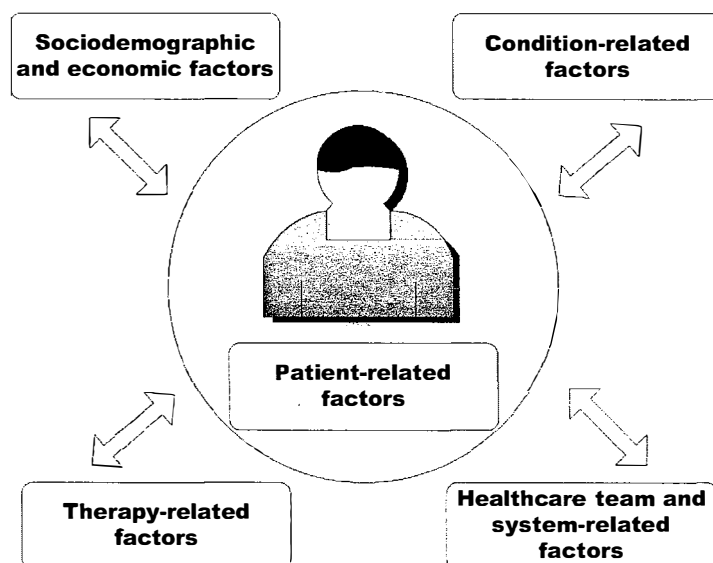

Figure 1.   Factors Affecting Patient Adherence (adapted from Cocosila and Archer 2004)

Patient-related factors are those that arise from patient psychology and attitudes. Most of the elements in this category are related to patient perception and beliefs about illness, condition, and treatment as well as to concerns, stress, and worries about long-term effects of the disease and medication [5, 18]. These factors have the most impact on direct adherence but they also mediate other categories of factors. For instance, improving adherence by modifying external factors is impossible for a patient who does not understand the necessity for disease monitoring.

One category of external influences is *socio-demographic and economic* factors. Socio-demographic traits such as race, age, gender, marital status, or health condition are obviously particular to each individual but cannot be influenced by him/her. Economic factors comprise elements related to socio-economic status, education, job, and family situation. Although there are reports of nuances in adherence due to socio-demographic and economic factors (e.g. seniors or adolescents seem to be less compliant than adults), in general these factors have little influence on overall adherence [5]. More puzzling, inferring some apparently logical conclusions (e.g. people with poor economic status are less adherent) has proved to be wrong [13].

Condition-related factors are another category of external influences. They are strongly related to illness stage and the subsequent effects: symptoms, disabilities, co-morbidity, progression of illness, and commonality of treatment [5, 13]. These factors can influence adherence directly, but also indirectly by modifying patient beliefs about their conditions. Studies have found that there is no direct proportionality between patient condition and adherence, as common logic may indicate. For instance, patients with more severe illnesses were less willing to participate in decisions on their treatment and to comply with a prescribed regimen, as compared to less seriously ill patients [13].

A third category of influences external to the patient is *therapy-related*. These refer to the way the therapy is offered (e.g. form of medication and treatment, duration, and availability of medical support when needed) as well as to the significance and timing of outcomes and, possibly, of side effects [5, 18]. This category of factors does not have a comparatively significant effect on adherence but tends to magnify other influences. For instance, some patients may develop side effects if they are not taking medication as prescribed. Erroneously, they may think medication is responsible for the side effects and may stop taking it, thus aggravating their medical conditions [18].

Healthcare team and system-related factors play an important role in overall patient adherence, especially through patient-healthcare professional relationships. Research is unanimous in showing that good patient-provider communication and a faithful relationship established during the "first encounter" between the two parties are essential for patient adherence to the subsequent treatment [18]. Many factors related to the healthcare team (skills, knowledge, workloads, and reimbursement) on one hand, and to the healthcare system (medication distribution, social attitudes, government regulation, and availability of news about diseases and treatments) may influence adherence negatively [5]. Even some unexpected combinations with patient-related factors might occur. For instance, a patient waiting too long for the first consultation with a very professional physician may "retaliate" by treatment non-adherence, despite the high quality of the actual consultation [18].

All in all, the factors affecting adherence are closely related, leading to some surprising and "non-logical" influences in some cases. Accordingly, 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.

3.   CAN MOBILE INFORMATION TECHNOLOGY IMPROVE ADHERENCE?

Despite its clear advantages, self-management of disease and conditions for outpatients poses problems in its practical implementation. The challenges arise from the peculiarities of both patients and the healthcare system, as well as from the manner the two parties exchange information related to the disease management process. Some of the most serious issues for chronically ill outpatients are related to non-adherence to treatment, and the related behavioural changes that are needed. Little can be done for patients not willing to comply with prescribed medication, for reasons under their own control, or for situations where the patient-provider interaction is inappropriately managed. However, in addition to clinical interventions targeting the pivotal barriers of patient health beliefs and patient-physician collaboration [20], information technology in general and mobile solutions in particular could address some objective problems of today's homecare that may 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" [21] and since today's care model has the drawbacks described above, it is justifiable to examine solutions to some of these problems by an information technology approach. Today's information technology offers tools (encompassed under the paradigms of e-Healthcare and m-Healthcare) to significantly improve health outcomes and the efficiency of the care process. Related to this, we suggest an innovative approach involving mobile information technology solutions as one possible channel to help overcome some outpatient adherence problems. This approach matches the recognized features of mobile solutions to some non-intentional adherence problems [9]:

- *Access.* Mobile services go everywhere with the patient, allowing continuous or frequent monitoring of health parameters and of medication-taking patterns. Also, mobile services allow anytime and anywhere contact with the healthcare system, for feedback, encouragement, support, or timely intervention, if necessary.

- *Quality.* Pervasive mobile solutions allow patients to receive better information through communication capabilities with the healthcare system and community/support groups.

This could improve adherence, confidence, activeness, education, and quality of self-care activities in general.

- *Value.* By being always available to patients, mobile solutions can help patients improve treatment adherence and make necessary behavioural changes while living an active and normal life. This would increase the possibility of early detection of medication side effects, co-morbidity associated with treatments, and unexpected health situations in general, thus reducing negative consequences for patients, and the social costs of illnesses.

Adherence is usually compromised by several elements working concurrently [22], and single-factor interventions are not productive [5]. Therefore, for maximized effectiveness and efficiency, mobile solutions to support adherence should target several factors simultaneously. Also, mobile interventions should be encompassed in more complex clinical models that would adopt a patient-centered perspective and involve specific elements depending on the patient, treatment, disease, and the healthcare system. Possible interventions through mobile solutions to cover several aspects of adherence would be similar to those provided by telemedicine and Web-based healthcare but featuring increased convenience and flexibility: monitoring, reminding, consulting, informing, supporting, and educating [9]. Table 1 summarizes the benefits of the interventions mobile solutions can provide in improving patient adherence, discussed in more detail on the following.

Table 1.   Suggested Interventions to Improve Outpatient Adherence by Mobile Solutions (adapted from Cocosila and Archer 2004

Intervention	Adherence factors involved	Possible benefits
Monitoring	Patient-related Condition-related Therapy-related	Diminishing forgetfulness, stress, and anxieties; Improving motivation, knowledge, and skills in managing the treatment and disease in general.
Reminding	Patient-related Condition-related Therapy-related	Reducing forgetfulness and treatment stress and anxieties; Controlling aggravating factors; Increasing optimistic attitude, self-confidence, and motivation.
Consulting	Patient-related Condition-related Therapy-related Healthcare team and system-related	Reducing the effects of stress, anxieties; Diminishing consequences of insufficient knowledge or skills; Improving self-confidence and optimistic attitude.
Supporting	Patient-related	Diminishing the feeling of isolation;

	Social and economic interventions	Providing encouragement; Improving self-confidence.
Informing	Patient-related / Social and economic interventions	Improving patient knowledge; Fighting patient anxieties, misunderstanding, and negative beliefs.
Educating	Patient-related / Social and economic interventions	Improving adherence following persistent and personalized application of the other interventions.

Monitoring. This includes some self-testing by the patient (e.g. blood glucose) and measurements (e.g. weight), and recording the results so as to track their variation in time, providing tighter control and management of the disease [23]. The data to be collected depends very much on the specific illness, patient, condition, and treatment. Compared to wired solutions (e.g. landline telephone or Web), mobile monitoring offers better flexibility and convenience by being always available to the patient. This allows close adherence to a rigorous time schedule, which may be mandatory for correct treatment. Efficient monitoring must be followed by feedback about test results and healing progression in general. Mobile solutions allow real-time feedback, with proven benefits for improving adherence and self-management of the disease [6].

Monitoring through mobile solutions would likely target some sources of unwilling non-adherence such as forgetfulness, testing stress and anxieties, as well as lack of knowledge and skills in applying the treatment, and managing the disease in general.

Reminding. This 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, etc. [24]. More effective reminding involves patient confirmation of having complied with the required action and, in certain situations, receiving feedback from the healthcare system about complying (e.g. to encourage positive performance and to discourage non-responsive behaviour).

Mobile solutions offer excellent opportunities for reminding because they are always with the user and allow real-time exchange of information. Furthermore, mobile devices currently on the market allow many different ways to convey notifications to patients (e.g. voice, text, and vibrations), thus reminding them in a personalized and unobtrusive manner.

Reminding through mobile solutions has the potential to improve patient adherence by decreasing forgetfulness, treatment stress, and anxieties, as well as reducing the impact of harmful factors such as smoking. Reminding, especially if followed by appropriate feedback, could foster optimistic attitudes, self-confidence, and motivation.

Consulting. Good relationships and communications between patient and the healthcare system are essential for adherence. Patients communicating with health professionals (e.g.

physician, nurse, or home care personnel) their health outcomes and feelings associated with the treatment is essential to optimize the curing process [6]. Conversely, some physicians have reported that remotely communicating with their patients (by email, for instance) improved the whole management of diseases in outpatient conditions [25].

Mobile solutions would be ideal for instant consultation, initiated by either patients or the healthcare system, when urgently required (e.g. patients notice a sudden unexpected side effect to a medication, or doctors notice test results going dangerously beyond prescribed limits). Compared to other channels of communication, mobile solutions offer the advantage of 'anytime and anywhere' for communicating with patients. They also provide greater flexibility through synchronous (e.g. phone type), asynchronous (e.g. text messaging or email), or mediated (through automated software performing basic routine tasks) transmissions [26]. As a higher level of flexibility and convenience, mobile technology already allows conversion of voice to text and text to voice thus adapting to various patient preferences (e.g. text messaging is popular among teenagers as compared to phone calls among seniors). A new and significant dimension could be brought to consulting and adherence in general by the use of camera phones.

Instant consultation, facilitated by mobile devices, would have the potential to improve adherence by diminishing the effects of stress, anxiety, insufficient knowledge, or skills concerning the disease and its treatment. In contrast to existing home and ambulatory care models, where access of outpatients to physicians is sometimes difficult when needed, instant consultation could give patients a feeling of self-confidence. It could also give them a more positive and optimistic attitude if they know that they have a virtually permanent connection with the healthcare system, especially if an alerting feature is included [23].

Supporting. Although today's patients are much more educated and informed about their health problems, especially from Internet sources, they still need human interaction, support, and counselling [5, 27, p. 212]. Social support and discussion with peers and other members of the community is also an important socio-economic factor that enhances adherence because it makes patients feel less isolated and more encouraged when they can access peer support easily.

As mobile communications continue to grow in reach and capability, they may help support adherence intervention with the same efficacy that Web support groups have demonstrated [6] but with the additional advantages of flexibility and convenience. For instance, today's cell phone applications already have built-in capabilities for voice conferencing and text messaging. A further leap forward may be the result of multimedia messaging services that allow not only image transmission but also dialogue with the wired Web. As in the situation of instant consultation, mobile applications allow a high degree of patient customization (e.g. conversion of text to voice and vice versa).

Informing. It is clear that modern patients have more information about diseases and treatments than a few decades ago, due to the rapid development of widely available media and, especially, the Internet. However, studies show that patients want to know more, whereas their physicians do not correctly estimate how much information they can provide.

As more informed patients would better understand the decisive role of adherence for the healing process, it is of interest to improve patient knowledge, because this would help to dispel misunderstandings, anxieties, and negative beliefs. Mobile solutions could not directly offer information to patients because of the limited input/output data entry and retrieval they offer. However, mobile devices such as cell phones could direct patients to valuable news in other media (TV and radio broadcasts, newspapers, or Web sites). This pointing to information sources could be of a 'push' type when initiated by the healthcare system or a 'pull' type when done at the patients' request. Mobile solutions would offer the advantage of being more timely in informing the patient about volatile sources of information (e.g. 'a radio broadcast of interest today, at noon').

Educating. Educating patients about dealing with illnesses and their treatments is an important factor for improving adherence. Since education is a more complex and lengthy process, it is difficult for mobile solutions (as for other types of online solutions such as Web-based education) to address this process adequately. However, a better education could be acquired through the constant application of the other mobile interventions we have discussed, stimulating a combination of productive information and action for the patient.

4. OBSTACLES IN ADHERENCE m-HEALTHCARE SOLUTIONS: THE DILEMMA OF PATIENT AND TECHNOLOGY ROLES

The analysis in the previous section brought forth arguments for the innovative utilization of mobile solutions that could improve adherence. Further investigation is needed to determine what technology would enable the proposed activities, possible obstacles, and what the patient roles would be as users of the technology.

4.1 Enabling technology

Interventions such as instant consultation with the healthcare system, prompt interventions for patients in need, peer and community support, and informing patients about interesting but volatile news sources provide a good fit with wireless technology support. Wireless is the only technology providing today that provides anytime-anywhere (within the area of coverage) features required by the above interventions. This technology has recently witnessed a tremendous amount of diffusion throughout society, especially due to cell phone communications (statistics show that over 1 billion mobile phones are now in use worldwide). However, despite the necessity for wireless technology, it is important not to overload the communication system with routine data exchange. Otherwise, health professionals could be overwhelmed with unnecessary call requests. Thus, patient wireless connection with the healthcare network should be used sparingly, usually following prior and periodic patient segmentation and prioritization.

Patient education, as shown in the section above, could be improved as a subsequent effect of all interventions. However, it is arguable whether wireless technology would be necessary for monitoring and reminding, the other two key adherence actions. In contrast to consulting, supporting, and informing, which require active patient participation, monitoring and reminding could be done, at least theoretically, without direct involvement of the patient.

4.2   Possible obstacles

Implementing the above technologies raises some technical, organizational, economic, and human obstacles. From the technical point of view, such services should be based on an open technology platform in order to be able to interface with various other devices and systems [6] already in place in the healthcare environment. This is a major problem that must be addressed early in the design process of the system since, in contrast to the Internet, mobile services are normally based on various proprietary standards and solutions [28].

Another important issue is that empowering outpatients with mobile healthcare technology with a view to improving their adherence would necessitate some alteration in the organization of existing home care systems. Thus, call centres would need to be created or, where they already exist, they would need to be enabled with capabilities for wireless communication and access to patient data storage and processing. This could generate resistance towards adopting such a project. Specialized personnel for maintaining the information technology infrastructure, as well as healthcare personnel (e.g. nurses) participating in communication and data exchange with patients and/or the responsible physicians would be necessary [9].

From the economic point of view, in-depth business analysis is required to balance the benefits against the costs of adherence-improving initiatives. A more complete analysis should mirror the savings generated by the reduction of direct costs (e.g. for treating chronic diseases and conditions) and indirect costs (e.g. for related social consequences) and the necessary investments and operating costs [9]. Telemedicine in general can prove its cost-effectiveness only if it provides at least the same level of service for outpatients while costing less than regular home care [29].

By far the most important barriers could come from the people who are the main component of any healthcare system. Patients could have discomfort with new technology and implementations. An additional major concern with any information technology solution is the security and privacy of data [6]. The most significant resistance is expected to come from health services providers. Physicians may fear being excluded from their current roles as major players by health insurance and disease management organizations and become "an appendage to a program that will save the health plan money" [30]. Other problems such as liability, extra workload, and reimbursement for supplementary services offered through wireless channels by physicians must be addressed thoroughly before deploying any of the proposed solutions.

4.3   Dilemma of patient and technology roles

Our discussion next turns to identifying appropriate patient situations for mobile monitoring and reminding. To improve adherence through mobile monitoring and reminding interventions there are two potential extreme approaches regarding the patient degree of involvement: total participation or no participation. The participative patient approach maximizes patient activities in performing tests, and recording results and other data about medication compliance. The non-participative patient is only wearing the necessary devices

but their actions do not require any conscious patient participation. Both ideas have advantages and disadvantages. They are analyzed in detail below and summarized in Table 2.

Table 2.   Patient and Technology: Extreme Types in Mobile Monitoring and Reminding

		Patient	
		Participative	**Non-participative**
		Consciousness of the program; Responsiveness; Optimistic attitude; Self-management.	Saves time; More reliable; Less stressful; Independent of knowledge and skills.
Technology	**Device-based**	Save air time; Increase privacy; Less obtrusive; Higher communication reliability.	
	Server-based	Timely informing of medical systems; Better feedback; Higher persistence; Timely undertaking of corrective efforts; Better collaboration with other adherence-improving efforts: consulting, supporting, and educating.	

Participative patient in monitoring and reminding. Monitoring in outpatient conditions is managed usually by the patient but in some special situations (e.g. lack of knowledge or skills, stage of the illness, or age) by other people (e.g. 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 the tests and tracking some health parameters by longitudinal comparison with previous outcomes [23], analyzing, and making decisions on the steps to follow, would tend to make the patient more optimistic and responsible.

Mobile technology can help the patient record test results and communications for future reference. Data could be recorded through various mobile devices (e.g. *Personal Digital Assistants* - PDAs, or cell phones) by typing brief strings of characters. Due to the input/output limitations of mobile devices (difficult typing, small size screen, tiny keys, etc.) voice input could be used as a more convenient approach, especially for less technically savvy patients (e.g. seniors). Voice to text conversion could be used for easy storage and retrieval of voice interactions. Irrespective of how test results are recorded, the related patient activity will make him/her better perceive the meaning of the data while managing it, thus increasing consciousness and improving the patient's attitude towards self-management. The same situation applies when a patient records online the information about complying with a treatment activity he/she was reminded about (e.g. taking a pill, performing a glucose test, etc.). The patient could enter compliance information by pressing a few keys on the mobile device or through a voice recording.

Positive patient attitudes could be further improved if the patient receives rapid feedback on his/her self-testing or drug taking activities. Feedback, either negative (e.g. discouraging bad attitudes) or, especially, positive (e.g. encouraging to perform the same way), would be confirmation of a beneficial trend. This would help to stimulate positive and active behaviour, optimism, responsiveness, and self-confidence.

The main disadvantage of the active patient approach is the danger of exaggerating patient activities, thus disturbing him/her through involvement in too many routine tasks. This can lead to a ricochet effect that could threaten and reduce adherence and hence the entire disease management process. For instance, a diabetic patient having to perform three glucose tests per day and to take five pills would presumably feel uncomfortable if reminded about every one of the above activities and, further, if asked to report on compliance each time. Therefore, the opposite approach could be envisioned: the non-participative patient.

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 his/her activities. In this case, automated tools would perform tests, store time-stamped results, and communicate them to a remote monitoring centre. For instance, blood glucose measuring devices that provide results to be communicated through cell phones have already been tested, and market analysts speak about the forthcoming integration of the two devices. This could be an advantage for active patients trying to live a normal life by going to school, work, or various other places without being disturbed by disease management activities.

Doing specific tests without direct patient participation would also have the advantage of diminishing test stress and increasing test accuracy. Results would not be influenced by the patient's lack of time or insufficient testing knowledge or skills. Smart devices would perform the tests, always by using the proper technique, and store or send the results following a prescribed schedule.

Reminding patients to take a certain medication could also be partially automated through a 'smart' pillbox. This would record or send information automatically about timing when the pillbox was opened for taking medication.

Having intelligent devices replace patient monitoring and confirming activities would have advantages in terms of convenience and unobtrusiveness. Also, due to increased accuracy and reliability, the outcomes of the treatment might improve, with attendant advantages for patient physical and mental state, treatment adherence, and healing process in general.

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 sides of the self-management of the chronic illness 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.

Besides 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 maximize treatment outcomes and efficiency. Two options are possible: storing the data in a mobile device (such as a PDA or smart phone) or sending the data wirelessly to 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 summarized in Table 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 the wireless channel with routine messages when the patient state is within acceptable limits and nothing abnormal occurs.

For patients complying well with the treatment and having self-measured health parameters within the range set individually by their physicians, the regular 'dialogue' would be only between the patients and their mobile devices. Only for readings or non-compliance (e.g. missed medication) going systematically out of range, would the mobile device contact the central system automatically (e.g. health personnel) for appropriate intervention.

This device-based approach has the supplementary advantage of patient privacy. For the usual situations the patient is exchanging data only with the personal device, thus avoiding possible unauthorized tampering with confidential health information. It would also be less obtrusive towards patient activity. No impromptu phone calls or SMS messages would disturb regular patient activities.

Moreover, dependence on wireless communications has an important disadvantage: temporary loss of connectivity. The shielding effect of geographical relief heights, buildings, vehicles, and even some weather conditions can make a wireless device lose connection with the network. Accordingly, patients trying to store or receive information remotely for monitoring or reminding could lose part of the data. In contrast to this situation, patient dialogue with applications stored on the mobile device is limited only by the reliability of the device.

Server-based technology. The alternative for storing data pertaining to monitoring and reminding, as well as for receiving appropriate feedback, is to use a server-based implementation. This would require patients using a basic wireless device (e.g. a cell phone or even a less sophisticated device such as a 2-way pager) to send and receive data from a central server administered by the outpatient's healthcare organization in charge of the disease management program.

This approach would offer the advantage of better monitoring of patient health conditions. All patient data would be immediately available to the healthcare organization, so abnormal situations would be detected promptly. The organization would be able to offer the automated

or fast and high quality human feedback (appropriate encouragement and/or criticism) that has been proven to be extremely beneficial in improving patient adherence. Medical professionals could also contact patients when indicated by data observation (e.g. for repeating some self-tests or for asking about possible symptoms or side effects, and even for recommending corrective actions). This would add a consultation role to the monitoring/reminding interventions, with beneficial effects for adherence. A related aspect is the improved facilitation of social support from peers/community through a healthcare moderator that has proved to be fruitful for patient 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 personalizing dialogue with the patient, in order to make it more productive. It is understandable for patients to prefer various types of communication depending on their age, background, and technical skills. For instance, text messaging is very popular among young people, but for professional drivers vocal reminders would be the only acceptable channel. Central storage of data and managing feedback and encouragement would also tend to make the use of a text to voice or voice to text conversion systems more feasible and reliable.

Except for lower communication reliability, centralization of data offers clear possibilities for longer time persistence. Central data storage rather than on the mobile device would eliminate the risk of accidental or intentional data erasure, of device failure affecting data, or of unwanted access to data by other individuals. Even if the mobile device is lost or stolen, data would always be in the system, available for future reference and comparisons. Having the possibility to inform accurately the patient about his/her treatment and condition evolution has the possible potential of improving mental support and adherence. Another advantage of this approach is the possibility of integration with other patient data information systems.

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 2. More intermediate situations could be possible in practice. 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 side. The target should always be increased patient adherence, and the least obtrusiveness for patients and healthcare professionals, while maximizing the overall effectiveness of adherence interventions.
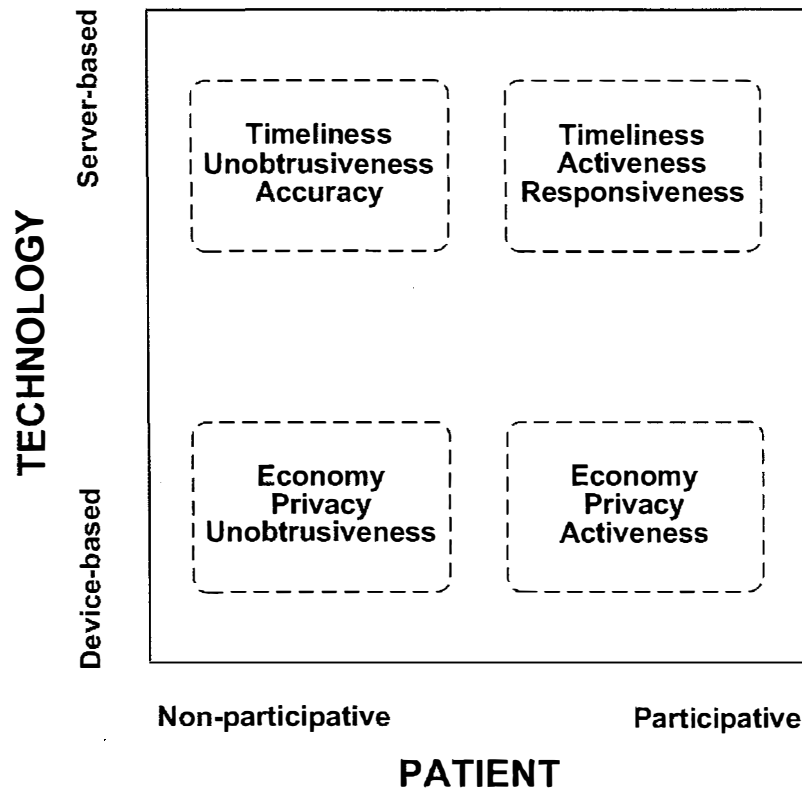
Figure 2.   Patient and Technology Conundrum in Mobile Monitoring and Reminding

5.   CONCLUSIONS

Global changes in today's society, the growing incidence of chronic illnesses and conditions, and the shrinkage of healthcare budgets has led to the increased importance of self-management of diseases in outpatient environments. The success of this newer approach is seriously hindered by adherence to medications and the necessary behavioural changes, which various studies have shown to achieve only 50% on average [31]. Poor adherence is a major source of concern for patients, medical professionals, healthcare system, and society.

Mobile solutions could help to address adherence in an innovative manner although these are not without possible barriers. Of the six possible interventions proposed by this paper to improve adherence, patient monitoring and reminding raise additional problematic issues regarding patient and technology roles. There is no optimal solution to these challenges and the best combination depends on a complex of factors: patient, disease, condition, treatment, and healthcare system possibilities.

Future research should examine 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 [32], as well as the changes required to the current healthcare system and related infrastructure required for supporting outpatients [9].

Despite the uncertainty and obstacles we have mentioned, further research into improving outpatient adherence by mobile information technology solutions may be 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" [5].

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