



McMaster eBusiness Research Centre

**m-HEALTHCARE INITIATIVES FOR IMPROVING OUTPATIENT
ADHERENCE: OPPORTUNITIES AND BARRIERS**

By

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**McMaster eBusiness Research Centre (MeRC)
DeGroote School of Business**

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ABSTRACT

This work is an investigation of the human and system opportunities and barriers, followed by a cost/benefit analysis for outpatient mobile healthcare solutions that could improve adherence to medication and a healthy lifestyle. The goal is to compare the motivators and demotivators for using the technology on one hand, and to identify the main financial aspects on the other hand. The work begins by defining the outpatient adherence problem and how mobile solutions could help. It then discusses the driving and resistance forces among the main stakeholders: patients, healthcare professionals, healthcare institutions, and government. Next it compares the adherence costs and the costs to implement mobile initiatives to combat non-adherence. The possible adoption of mobile healthcare initiatives to address outpatient non-adherence, although beneficial, also creates concerns of varying degree for all the major stakeholders. These must be addressed before implementation in order to maximize the chances of success.

KEYWORDS

Outpatient, Adherence, Information Technology, Mobile Healthcare, Business Case

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1. INTRODUCTION

Today's society is facing a serious challenge in terms of healthcare provision because of the increasing gap between the healthcare demands of the population and the human and financial resources required to meet these demands. The gap is further aggravated by the growing incidence of chronic diseases and conditions as well as an aging population with its higher susceptibility to health problems [1].

A possible response to the above challenges is to improve the management of some chronic illnesses in outpatient conditions, thus avoiding or minimizing primary and acute care costs. This would allow patients to live a quasi-normal life (e.g., going to work, school, shopping, etc.) while improving the medical outcomes and quality of care [2]. Sadly, any initiative towards outpatient care is seriously hindered by low adherence to prescribed medication and lifestyle changes that studies show to be only 50% on average. Non-adherence has become “a veritable epidemic” [3] of modern society, with complex consequences (medical, social, and financial), and non-adherent patients represent nearly 6 percent of hospital admissions (almost 2 million a year) in the U.S.A. alone.

Patients, as members of contemporary society, want to be active and mobile because life itself has become more dynamic in recent years. Furthermore, today's patients are better informed and technically savvier than ever. Accordingly, they are prepared for and expect healthcare solutions to address health problems by offering the same level of efficiency and technology as other sectors such as electronic commerce or banking [4].

This leads to the idea of an innovative approach in improving patient care and quality of life while providing total mobility for an active life style in an outpatient environment, supported by mobile health solutions. However, this approach will not succeed unless outpatient adherence problems are addressed properly. The problem of patient adherence is multifaceted and not well-understood.

Furthermore, “current methods of improving adherence for chronic health patients are complex, labor-intensive, and not predictably effective” [5]. Previous exploratory work has described factors influencing patient adherence and suggested several directions of action, where mobile solutions empowered by wireless technology may help [6]. Adherence may improve if mobile solutions are embedded in wider adherence-improving initiatives that include healthcare professionals, treatments, medications, etc. [6]. Although such a cutting edge technology approach seems attractive, a more detailed analysis must take into account human and financial barriers that may slow or hinder its wide adoption.

This study reflects the human and system motivators and demotivators for adopting mobile solutions to improve outpatient adherence on one side against the financial gains and costs on the other side. The viewpoints of major stakeholders in outpatient healthcare are analyzed (patients, healthcare professionals, healthcare institutions, and government) and differences between several categories of savings and costs associated with the implementation of mobile technology are outlined. The remainder of the paper is organized as follows: Section 2 discusses the motivators and benefits for m-healthcare solutions, Section 3 identifies several categories of human and system demotivators and obstacles, and Section 4 presents a cost/benefit analysis. Finally, Section 5 presents some conclusions and possible directions for further research.

2. M-HEALTHCARE MOTIVATORS AND BENEFITS

Innovative mobile information technology solutions to improve outpatient adherence may attract the interest of the major stakeholders in the healthcare system. This section describes the opportunities and

motivators pertaining to the main actors in an outpatient care management system. A synthesis of these benefits is presented in Tables 1 and 2.

*** Insert Table 1 about here***

*** Insert Table 2 about here***

2.1 Patient Motivators

Recent research has demonstrated behavioural changes to be of the utmost importance in influencing patient health states in general [7]. Encouraging behavioural transformations towards a healthier lifestyle is acknowledged as being at least as significant for a chronically ill person as the treatment itself. It is also clear that behavioural changes must be individualized for each patient since every person is unique. Mobile technology offers the distinctive possibility of personalization, thus allowing the high customization of interactions with patients, seen as “segments of one” [8], with the healthcare providers. Change of patient behaviours regarding their condition and lifestyle in general would therefore result in positive medical and social consequences.

Medical reasons

The concept of telemedicine is not new [9]. It has been traditionally supported by regular mail, landline telephones, and more recently, the Internet, to connect outpatients with the healthcare system. Mobile solutions are superior to these because they offer anytime and anywhere service to patients, irrespective of their physical location. Thus mobile solutions may be better for fulfilling the requirements of long-term home care. This does not imply patient neglect, but instead means fostering continuing contact between them and the healthcare system. Such continuous contact is more likely to predict and avoid serious complications since “preventing is better than curing” [10]. Mobile solutions would also help to

combat the outpatient non-adherence that often leads to collateral complications and even to the triggering of other diseases.

Social reasons

Non-adherent patients not only suffer medical complications, long treatments, and hospitalization, but also face absenteeism and intangible consequences such as psychosocial complications (e.g., isolation, damage of social status) and lower quality of life [11, 12]. Obviously, patients are interested in living a life as normal and active as possible, amid family, friends, and co-workers, rather than in a hospital environment. Therefore outpatients are likely to be interested in solutions allowing them mobility at work, school, vacation, etc. while at the same time having a virtual permanent connection with their healthcare providers. In this way, patients with certain diseases could live a better quality life while following the necessary treatment (e.g., performing self-tests, taking prescribed medications, following certain diets, pursuing physical exercise, etc.). Mobile solutions, by virtue of being customizable and always accompanying the person, should facilitate a high degree of patient involvement in the self-management of their diseases and conditions. This should improve patient adherence and help them to progressively develop responsive attitudes, self-confidence, optimism, satisfaction, and improved education and mobility [12].

2.2 Healthcare Professional Benefits

Today's healthcare professionals acknowledge that patients have views and feelings that must be taken into account. Accordingly, medical decisions should be based on collaboration and partnership between patients and their healthcare providers [13], and this involves a close and continuous dialogue. Mobile solutions would help to foster better communication with patients and also encourage active involvement in their own care.

Increased adherence of outpatients to prescribed treatments can reduce waste of professional resources caused by unnecessary appointments, consultations, and lab tests. For instance, a randomized controlled trial of telecare for patients with type 1 diabetes and inadequate glycemetic control showed that remote care can have a small positive impact on glycemetic control [14]. However, the authors of the study believed that the most important outcome of telecare in this case was in the health professionals' time: nurses had more time for feedback and that led to more frequent and beneficial treatment adjustments.

Another benefit for health professionals is in the reduced likelihood of litigation regarding treatments provided to outpatients. Since mobile services would allow permanent contact with patients, timely detection of abnormal situations would allow more rapid response, thus reducing the likelihood of degradation of patient state of health and possible subsequent complaints and litigation. This would help to increase the satisfaction and confidence of healthcare professionals.

2.3 Health Insurance and Disease Management Company Benefits

Disease management companies (e.g., *Asthma Disease Management, Inc.* of Philadelphia, Pennsylvania, or *CorSolutions* of Rosemont, Illinois, both in the U.S.A.) are a relatively new approach to developing disease management programs for specific illnesses. Insurance and disease management companies are major promoters of outpatient treatment approaches [15]. While health insurance companies are likely to be interested in cost reduction, disease management companies work towards more effective and efficient patient support activities.

With recent advances in evidence-based medicine, health care responsibility has tended to become more professional group-managed [16]. However, successful disease management programs or the more recent customer-focused health management programs must be more highly tailored towards

the patient needs, perceptions, and preferences. Because mobile solutions physically travel with the patient and provide constant interaction with the healthcare system, they are the ideal means for supporting individualized exchanges of information.

2.4 Government and Society Benefits

Contemporary society is witnessing an acute contradiction between the increasing demand for quality health care services and the limited resources to meet that demand [4]. This demand arises from patient requirements for higher quality care, but there are also quantitative explanations: a growing incidence of chronic conditions and diseases in an aging population. On the other hand, there is a growing shortage of resources:

- fewer hospital beds and healthcare personnel [1];
- physicians can spend less time with patients as waiting lists are growing [17];
- a falling percentage of the population who are employed and who can support the healthcare system through taxation.

A modern answer to the above contradiction is to treat more chronically ill people as outpatients, by delegating certain self-management tasks to the patients themselves. Although this process should work well theoretically, in practice it is seriously constrained by lack of patient adherence to prescribed treatment regimens and lifestyle changes. Non-adherent patients divert resources from people who really need them in acute care, thus causing sub-optimal overall clinical benefits and general waste [11, 12].

Society should therefore be interested in solutions that improve outpatient adherence to medical treatment and necessary lifestyle changes. Evidence shows that dealing with chronic diseases and conditions is a long-term continuous process that cannot be replaced by episodic and time-constrained visits with primary care physicians or through periodic home care visits [18]. The latest versions of

certain information technology tools can help responsible patients to assume routine self management duties, thus reducing the drain on healthcare professionals (e.g., field data collection by home care nurses, or regular home visits) leading to global savings in the work force and to improved quality of life for patients [14]. Even if, on the whole, telecare activities do not save the time of health professionals, resource allocation would provide a better match to the care needs of the patient population.

Advances in information technology have the potential to alleviate some of the conflict between finance and health ministries. Information technology that focused on outpatient adherence would also fit into the contemporary picture of a revolution “under way in health care” since “after decades of patriarchal provision of services, governments are now accepting that patients should have a say in what is provided” [19].

3. POSSIBLE m-HEALTHCARE DEMOTIVATORS AND OBSTACLES

In contrast to the advantages and benefits discussed above, mobile information technology approaches directed to improved outpatient adherence would also encounter barriers and demotivators. Two types of such obstacles are expected: financial and human. This section depicts the human and system barriers, and financial aspects are addressed in the next section. The expected benefits and barriers for various categories of stakeholders are presented in Tables 1 and 2.

3.1 Patient Issues

Intrinsic factors

Patient-related factors are clearly pivotal for any adherence-related issue [11, 12]. These factors spring from patient psychological, attitudinal, and behavioural traits and are associated with beliefs and concerns about disease, medication, and treatment as a whole. Even the most competent healthcare

professionals are unable to improve patient adherence without their active and conscious involvement. For instance, little can be done for a patient who is in a state of hopelessness about the treatment for his/her illness, although the actual disease may be benign. In situations when patient-related factors of adherence are not favourable to healing interventions (e.g., patient does not accept being monitored or reminded about taking medications), the most advanced technology is useless.

Difficulties with technology

Despite patient willingness to adhere to a treatment by using novel information technologies to improve performance, difficulties may occur with some patients in following recommendations. For instance, although research has shown that social and demographic factors (e.g., race, gender, age, social status, education) have a minor influence on adherence [12], elderly patients appear to have an objective tendency to poor adherence and involvement in their treatment because of cognitive and functional impairment. If mobile devices pose usability problems, especially due to their limited input/output capabilities, it is likely that elderly patients will have difficulties in using any complicated mobile device. Besides seniors, some other categories of people (e.g., low income or minorities) may exhibit discomfort and resistance to using cutting edge technologies and devices because of a lower level of experience or familiarity [20]. Other patient categories that may have difficulties with mobile device support include those who for various external reasons (e.g., factors related to their conditions, therapies, healthcare teams, or even the healthcare system) have difficulties in adopting pro-adherence attitudes [12]. In addition, complex and non-robust devices and programs are more likely to be rejected by patients [21].

Interaction with devices

There are also questions regarding patient interactions with mobile devices. For example, would patients prefer highly automated devices to perform medical measurements (e.g., blood glucose or

blood pressure) and transmit the results to a homecare call centre, or would they prefer to be actively involved in this process? The first approach may be more convenient but may not be welcomed by patients who would like to be better informed about their health status and treatment, and to be involved actively in their treatment.

A related issue is how ‘tightly’ to design the patient interaction with the mobile device. Trying to collect or to remind “too much data too often” [21] through a mobile solution may unnecessarily irritate the patient and seriously hamper the whole adherence-improving initiative.

Patient discomfort with limited input-output capabilities of mobile devices is also an important issue. Trying to enter/receive a large amount of written information through mobile devices is much more difficult, as compared to a desktop or laptop computer.

Security and privacy

Telemedicine technology requires appropriate encryption to ensure patient trust when transmitting personal data online. A still very popular opinion is that wireless communications have a lower level of security and privacy than those using wired channels. Patients may therefore be reluctant to use wireless devices to exchange data about their health condition and treatment, even if these data are unlikely to be critical or sensitive. However, security and privacy of wireless communications in healthcare are regulated. The U.S.A. has issued related guidelines through *HIPAA (Health Insurance Portability and Accountability Act)* whereas Canada has adopted *PIPEDA (Personal Information Protection and Electronic Document Act)* and other pending regulations affecting health information that set regulations on healthcare data control.

3.2 Healthcare Professional Uncertainties

Outcome measures

There is a continuing discussion in the medical literature regarding the accuracy and reliability of adherence measurement. Four generic strategies for measuring adherence are most popular [6, 12]: subjective (clinical), objective, biochemical (pharmacological), and clinical outcomes. It is clear that it is difficult to accurately estimate the outcomes of any adherence-improving initiative, including those involving mobile solutions. The problem is further complicated by the time frame of the expected results: some initiatives may produce immediate outcomes, while others are restricted more to the long-term. Consequently, healthcare professionals may reject such approaches if the outcomes do not appear worthwhile.

Reimbursement

Currently many healthcare systems have no mechanism to reimburse physicians and other healthcare professionals for time spent interacting remotely with patients or in analyzing patient data, unless the patients are physically present. Accordingly, from the healthcare professionals' point of view, telemedicine is in general more suitable for providers receiving a fixed salary (e.g., in managed care programs) than for those in fee-for-service programs [22].

Overwork

Researchers have pointed out that it is impossible to launch new healthcare initiatives that require more work when healthcare professionals are overworked, because of a shortage of staff and financial resources. The healthcare system may be over-stressed by patient-initiated synchronous interactions that may compromise the anytime/anywhere channel of communication offered by mobile solutions. For example, recent research has shown that only about 13% of doctors currently exchange emails with their patients [23]. The main reasons for this are: time waste, medical and legal issues, and patient difficulties with email. Therefore it is expected that, in the absence of an appropriate reward

mechanism for time spent dealing with online patient issues, attempts to involve healthcare practitioners in such initiatives may fail [4].

Work pattern changes

Physicians may have major concerns about remote disease management programs if these initiatives remove them from their current central roles of providing healthcare. Specifically, they may fear that health insurance and disease management companies would make them “an appendage to a program that will save the health plan money” [15]. For example, disease management company nurses may “unintentionally circumvent the treatment plan” [15] while managing outpatient care, and they may consequently interfere with the relationships between physicians and their patients. The liability problem is equally complicated: disease management companies might not interfere directly in the implementation of physician-prescribed treatments, but could support patients by monitoring them and alerting physicians when interventions become necessary. According to Chin [15], in this scenario physicians would still bear the liability, even if healthcare companies did not reimburse them for the extra time allotted to homecare services.

An important aspect is the attitude of physicians towards information technology and sourcing, based on culture or work habits. Although providing patients with mobile devices that helps them to improve treatment adherence might not mean a significant challenge for physicians in terms of technology use, this type of initiative would also require physicians to more actively utilize information technology. Although this may cause difficulties for physicians who have little experience with information technology, it will be less of a problem for younger cohorts of physicians currently entering practice with a much greater exposure to information technology in general.

Taking into account all of the above physician concerns, it is clear that mobile services meant to further expand existing homecare services might not be warmly welcomed by physicians, unless they could be motivated by personal gains in addition to better care for their outpatients.

Medical issues

Communications between patients and physicians in a mobile context may also create a liability issue. For example, who bears the responsibility if physician recommendations or advice are not received and understood by patients because of temporary loss of connectivity or a low ratio of signal to background noise? 100% connectivity is not a realistic goal because of the shielding and distance effects of geography, buildings, and vehicles. Therefore, transmitting critical information to patients through mobile devices should include a requirement for patient acknowledgment.

Research has reported consistently that social support, encouragement, and rewards can significantly improve certain outpatient health behaviour and lead to higher adherence [12, 24, p. 212]. Consequently, creating online discussion groups similar to those already existing on the Internet [21] could be beneficial. However, in this situation there may be also the problem of liability: would physicians be responsible for patients who choose to alter their prescribed treatment in order to follow advice received from peers in discussion groups?

Security and privacy

Mobile solutions, as is the case for telemedicine in general, raise medical-legal issues regarding how much data could be stored on fixed/mobile computers of healthcare practitioners, and how easily this data can be accessed in an emergency [22]. Storing data centrally (e.g., in a hospital database) would offer the advantage of better data protection (e.g., reduce risks of accidental/intentional data erasure or device loss/theft) and management (data updating and longitudinal tracking) as well as improving the

potential to integrate with other medical data systems (e.g., other hospital data). However, central storage of data would mean a more intense use of communication channels, with possible technology drawbacks (e.g., channel overflow, loss of connectivity, and concerns about third party interference with data).

3.3 Health Insurance and Disease Management Company Issues

Although health insurance and disease management companies tend to favour new initiatives in telecare, especially in remote patient monitoring, these firms also have some issues that must be resolved for successful implementation of such systems. Three important criteria must be taken into account when selecting a mobile technology application: infrastructure requirements, device capabilities, and integration with existing systems [25]. Integration is a matter of technical compatibility (allowing different systems to communicate faultlessly and timelessly) and cost (avoiding high costs of transformation and adaptation between systems). Besides these obstacles to outpatient care, some important issues to these companies and other stakeholders are [25]:

- unknown impact on user productivity and workflow;
- existence of support for technology if required;
- vendor stability in an emerging market;
- confusion over the large number of similar products on the market;
- unanticipated consequences on the work environment;
- concerns about the learning curve with new technology; and,
- reluctance to invest in a leading edge (and, hence, immature) technology.

Economies of scale are also an underlying problem. Investment costs for mobile healthcare initiatives tend to be high and can be justified only if a sufficiently large number of outpatients participate. As patient numbers increase, a subsequent problem arises: the need for uniformity to keep healthcare professional work volume and system operating costs down on one hand, and the

requirement for a patient-centred approach on the other hand. Modern healthcare is oriented towards customer-focused management, which considers each patient as unique, with peculiar illnesses, co-morbidities, and treatments. This conflicts with a mobile healthcare system that, for efficiency reasons, would need to automate a great deal of remote interaction and dialogue with patients.

3.4 Healthcare System Concerns

From the point of view of the healthcare system, the main funder and stakeholder, mobile services addressing outpatient problems may face technology and human obstacles.

Technology obstacles

It is necessary to think in strategic terms when considering technology. Thus, an open platform should be adopted in order to facilitate interfaces with existing or future systems [21]. For instance, a disease management tool to improve outpatient adherence to treatment of diabetes must communicate with hospital databases and disease management programs for other diseases [22]. A technology should be chosen that is general, but at the same time is customizable, in order to accommodate the needs of various categories of outpatients. These technology problems must be addressed early in the design process since mobile services based on proprietary standards and solutions [26] could result in huge integration obstacles.

Human barriers

From the healthcare system's viewpoint, organizational and healthcare employee obstacles may be significant. Implementing mobile solutions for outpatients on a wide scale would necessitate an alteration of existing home care systems. Call centres that handle remote monitoring, reminding, and dialogue with patients would need to be created or enhanced, within the context of existing organizations such as hospitals, *Health Maintenance Organizations* (HMOs), or the *Community Care Access Centres* in the Canadian province of Ontario. Where such call centres exist, they would need to

be modified to handle wireless communication and data exchange with patients, as well as automated data storage and processing. Consequently, new jobs may need to be created or existing jobs altered in order to provide call services with appropriate personnel (e.g., technical support for information technology, and patient support for healthcare issues). Other jobs (e.g., visiting nurses) would need to be re-designed and personnel re-trained, or personnel re-assigned to other tasks, since some of the more routine issues would be made the responsibility of patients empowered with mobile technology. Understandably, healthcare employees may resist these changes.

Resistance to change may arise among some or all of the stakeholders during the implementation of mobile services, since this may alter existing patterns of working and living. Therefore implementation plans must be designed with relatively easy to reach intermediate targets so as to gain the confidence of stakeholders and to motivate cooperation.

4. BUSINESS CASE

Extensive research has stressed the financial implications of adherence. Virtually all studies show that the drift away from prescribed medication and treatment by outpatients generates large financial losses and a decline of life quality:

- medication non-compliance costs the U.S.A. \$100 billion and 125,000 lives per year [27];
- “more than \$113 million” (\$89 million U.S.) “worth of prescription drugs in Canada have been wasted due to non-compliance or a change in drug or dosage” [28];
- “annual hospitalization cost of medication noncompliance” is “US\$0.735 billion in Ontario, Canada” and “US\$13.35 billion in the U.S.” [29];
- hospitalization costs due to non-adherence represent 0.8% of all health-care costs in Ontario and 1.7% in the U.S.A. [29].

As there is a direct relationship between non-adherence and its impact on chronic patients, the negative implications of non-adherence are even higher:

- medical care for the 90 million chronically ill Americans represents 75% of the \$1,000 billion national annual medical costs [15];
- non-infectious chronic diseases with the highest social costs in the U.S.A. are: cardiovascular (affects 60 million people and costs \$300 billion per year), diabetes (affects 16 million and costs \$98 billion), and asthma (affects 15 million and costs \$13 billion) [15];
- high incidence of chronic illnesses in Canada is one of the causes of increased healthcare costs that now total about 10% of the nation's gross domestic product [30].

This study identifies several categories of costs and savings, and their breakdown is presented in Figure 1, which is discussed in more detail in the following.

*** Insert Figure 1 about here***

4.1 Financial Costs of Non-Adherence

Breaking down the overall cost figures, a more refined analysis reveals that non-adherence costs are of two types: intrinsic and illness-related.

(a) Intrinsic costs of non-adherence quantify the actual waste of not taking a medication or not attending a consultation or missing a prescribed test. For instance, the overall cost of missed appointments in England alone amounts to £400 million (\$716 million U.S.) per year [31]. The same study reports on an initiative of *Homerton Hospital* in Hackney, East London, to remind patients about upcoming appointments through an automated wireless SMS (Short Messaging System) service. At 5 pence (\$.09 U.S.) a message the cost was “more than offset by the savings in reduced missed appointments” (approximately 8%).

Although it is clear that these costs cause financial loss to patients and the medical system, it is difficult to draw general conclusions. For instance, some treatments involving expensive medication revealed the paradoxical situation that “unprovided treatment offsets the cost of increased morbidity” [32]. Similarly, Hepke et al. [33] report that a longitudinal survey of 57,687 diabetic patients showed that increased adherence did not lower the medical costs since the expected reduction in medical services (e.g., hospitalization) was offset by increases in medication charges (e.g., drug expenses).

(b) Illness-related costs of non-adherence represent the costs of diagnosing and treating conditions and morbidities triggered and/or aggravated by poor adherence [28, 32]. The cost of medication or behavioural non-adherence is present in the social costs of chronic illnesses and is a pure waste. As shown above, and confirmed by Chin [15], society is paying a disproportionately high price for managing chronic illnesses. Chin also mentions that there are growing initiatives, especially from health insurance companies, to increase adherence in an attempt to lower social costs. These costs

represent an important part of the price that society is paying for the inappropriate management of chronic diseases.

4.2 Savings Generated by Adherence

Treatments are commonly judged in terms of either or both their effectiveness and cost-effectiveness. A more general estimation of benefits from all disease management programs for all diseases can be expressed in terms of quality-adjusted life years (QALY) which is a measure for improved health [22]. Improved outpatient adherence is targeted to better management of chronic diseases in out-of-hospital conditions. The financial impact would reportedly be on the order of “\$8 billion annually in Canada, and \$80 billion in the U.S.” [34]. Savings would be of two types: direct and indirect.

(a) Direct savings refer to the decrease of costs for medical services (e.g., hospitalization, visits at the primary care centre, ambulatory care) and medication. For instance, based on Iskedjian’s [34] work which investigated 15 studies of hospital admissions with a total of 6,144 patients, \$1.7 billion (\$1.3 billion U.S.), of which \$1 billion (\$.8 billion U.S.) are hospital-related costs, are annually spent in Canada because of non-adherence to prescribed medication.

Various other studies reported cost savings of home telecare attributable to the reduction in hospitalization costs:

- 83% decrease in the admission rate and 86% decrease in readmission charges for patients with chronic heart failure [35];
- reduction from £454 (\$812.6 U.S.) a week for full-time residential care to £250 (\$447.5 U.S.) for private home care in the U.K., according to the *Royal Commission on Long Term Care*. The economic justification for transferring care to a home-based environment is augmented by an improvement in the quality of care and outcomes in home care conditions [2];
- a telemedicine program tailored for patients with type 1 diabetes led to the same level of metabolic control as traditional programs but had a cost of 650 Euro (\$800.7 U.S.) per year per patient less [22]; and,
- several reports from the U.K. and U.S.A. state that 14-46% of activities currently fulfilled by on-site nursing could be replaced by telecare, with net savings amounting to £1.26 million (\$2.25 million U.S.) per annum for a typical U.K. area health community and \$60-85 per patient per homecare activity in the U.S.A. [2].

Diabetes is one of the most serious cost problems for modern healthcare [15]. It costs about \$9 billion per year in Canada and \$98 billion per year in the U.S.A. [36] and the figures are expected to worsen in the next decades due to population ageing. The European *CODE-2 (Cost of Diabetes in Europe – type 2)* study revealed that only 28% of diabetic patients achieved good glycaemic control by systematic attention to all the steps required for the self-management of this disease [12]. The medical care of complications for these non-compliant patients was 3-4 times higher than in cases of good control of the disease. Most of the direct costs (about 30-65% of the total for the disease) were due to hospitalization necessary to treat long-term complications such as heart problems. The study further mentioned that the overall cost of treating patients with type 2 diabetes is already over 1.5 times higher than the average per capita health care expenditures and may further increase 2 to 3.5 times once patients develop preventable circulatory morbidities [12].

Outpatient telecare also potentially increases the savings of regular homecare, when compared to primary care, because more homecare services are handled by nurses thus saving clinic space, physician time, and costs. A study by Chase et al. [37] demonstrated, in a 6-month survey of 63 diabetics in the U.S.A., that the cost of modem transmission of glucose level data was \$163 for the 6-month period while the average cost of care for a single clinic visit was \$305. Similarly, Baldwin et al. [38] showed that telemedicine support for specific information acquisition also helps primary care in achieving “a reduction of 75% in outpatient clinic appointments”.

(b) Indirect savings are the reduction in personal and social costs generated by the chronic illness (e.g., absenteeism, early retirement, or premature death). For instance, personal costs generated by adherence-induced illnesses total \$517 million (\$409 million U.S.) while productivity losses (e.g., lost salaries or work time) amount to \$465 million (\$368 million U.S.) annually in Canada alone [34]. Various studies have shown that indirect savings are potentially very large, with indirect costs of non-compliance at least equal to direct costs:

- half of the \$7 to \$9 billion (\$5.5 to \$7.1 billion U.S.) prescription non-compliance costs in Canada in 1998 were generated by losses in work resources [30];
- \$54 billion of the \$98 billion U.S. cost of diabetes in the U.S.A. represents indirect costs due to disability and social problems [21];
- according to the *CODE-2* study, the indirect cost of diabetes in Europe is about as large as the direct costs [12]; and,
- loss of work time and decreased worker productivity significantly magnify the \$5.1 billion and \$12.4 billion losses due to asthma and depression, respectively, in annual direct medical costs in the U.S.A. alone [39]

Substantial savings can be achieved in terms of reducing absenteeism through compliance-enhancing actions: “\$290 per hypertensive employee, \$631 per employee with heart disease, \$1710 per depressed employee and \$1458 per diabetic employee, expressed in U.S. dollar values for 2000, from the point of view of the employer” [29]. Similarly, Biermann et al. [40] showed in a German study that the telecare of 46 diabetics through a combination of modem and regular phone over a 8-month period produced similar results in terms of medical outcomes, as compared to conventional care. The indirect savings from the telecare system were about 650 Euro (\$800.7) per year per patient because of reductions in travel time and missed work.

4.3 Cost of Implementing m-Healthcare Adherence Initiatives

Since there are multiple serious consequences of adherence, it is clear that even small gains in terms of outpatient adherence would be beneficial. However, a complete analysis must also include the effort and cost required to achieve that gain, in the face of possible obstacles to the proposed mobile healthcare initiatives.

This paper focuses on mobile healthcare initiatives alone, although adherence-improving solutions have multiple aspects. Since research in mobile healthcare is relatively new, limited reliable information is available, and most of it deals with remote monitoring interventions through wired channels (e.g. Internet or landline telephone). Little information is available on the related investment

in central infrastructure that would be required (e.g., servers, computers, software) but some market analysts are generally optimistic about the device and operating costs:

- “it costs \$5 to \$10 per day to equip a patient with a remote-monitoring system while an emergency-room visit costs an average of \$900” [36];
- a device to remotely monitor diabetes “will cost about as much as a single trip to the local emergency room” [41]; and
- operating costs of remote monitoring initiatives have the potential to be very low [31], especially if solutions would be highly automated and use patient segmentation and prioritizing [42].

Although health insurance and disease management companies appear to be interested in supporting such telecare initiatives, some analysts believe that, due to potential improvement in quality of life, patients would be willing to pay at least part of the costs: “People who have diseases such as asthma and diabetes are more motivated than the rest of the population and more likely to pay for these devices” [41]. A study performed by Barner, Mason, and Murray [43] on 116 adult asthma patients revealed that outpatients would be willing to pay a mean amount of \$29.50 U.S. for a self-management program in total. This work also revealed that patients would be willing to stay in such a program for 8 weeks on average. Both the amount and the duration were influenced by several patient factors such as health state and history, education about the disease, and access to health care.

As adherence improvement is multi-faceted, more in-depth research is needed, taking into account various factors that affect the business case for deploying outpatient mobile solutions. Telemedicine can prove its cost-effectiveness in such situations only if it provides to outpatients at least the same level of monitoring and care, in general, while costing less than regular outpatient care. Also, a more complete analysis must identify the economies of scale that are necessary to support both the initial investments and ongoing operating expenses.

5. CONCLUSIONS AND FUTURE RESEARCH

The fiscal challenges to modern healthcare have increased the tendency to shift patient care to ambulatory conditions while at least maintaining the same quality of care, compared to clinical and hospital settings. Unfortunately, the success of this approach to healthcare is hindered by outpatient non-adherence.

Mobile solutions may help in addressing patient non-adherence, with positive human and financial benefits for all major stakeholders: patients, healthcare professionals, health insurance and disease management companies, and governments. At the same time, most of these stakeholders face barriers in adopting such solutions for various reasons: behavioural, organizational, or technological. The business case is equally problematic and a detailed field analysis of the costs and benefits is yet to come. “Reimbursement, mobility, and physician issues are key links that must be connected to improve the value chain of remote patient monitoring” as suggested by *Disease Management News* [44].

A more in-depth analysis is needed of the changes required to existing outpatient care systems in order to accommodate a widespread mobile healthcare approach to improve patient adherence [2]. This analysis must take into account the present value of the redistribution of resources (human and financial) over a reasonable time span (a few years at least), as well as mandatory healthcare system activities, in order to address all the issues that are involved.

Future research must address more carefully the business case around the deployment of mobile solutions for improving patient adherence; it is acknowledged in the literature that not the technology or the application, no matter how attractive they may look, determine the success of an information technology application, but the business case behind that application [26]. Possible research topics could address the implementation and operating costs for several chronic diseases with high incidence (e.g., asthma, diabetes, congestive heart failure). Further research could determine if and how much the

patients, as direct beneficiary, would be willing to pay for the deployment costs (e.g., cost of mobile devices) or operating costs (e.g., cost of wireless communications). Also this research could identify the financial support other healthcare stakeholders (e.g., health insurance and disease management companies) or other stakeholders (e.g., mobile network wireless service providers or advertisers) would be willing to undertake. Research should identify to which extent business models for particular diseases (e.g., diabetes) are suitable to other diseases (e.g., asthma) and the corresponding critical mass necessary for financial success. Obviously, the outcome of this research would be of the outmost interest in further decisions regarding the possible utilization of mobile solutions for improving outpatient treatment adherence.

Despite the uncertainties and obstacles mentioned in this paper, further research on improving outpatient adherence by mobile information technology solutions is likely to be very worthwhile, because of the widespread interest in the adoption of advanced technologies in healthcare. A particularly important motivator is the fact that the medical world acknowledges that enhancing adherence appears to be more effective than the treatment itself [12].

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Tables

Table 1. Mobile Solutions to Improve Outpatient Adherence: Patient, Institutions, and System Opportunities and Barriers

Stakeholders	Motivators and Opportunities	Demotivators and Barriers
Patients	<p>Medical reasons</p> <p>Anytime-anywhere total mobility; Permanent contact with healthcare; Better quality of health services; Higher quality of a quasi-normal life; Predict and avoid serious health complications.</p> <p>Social reasons</p> <p>Reduced absenteeism; Better social integration; Develop a responsive attitude, self-confidence, optimism, satisfaction, and improved education; Patients are interested in and savvy about technology.</p>	<p>Intrinsic factors</p> <p>Patient-related factors (psychological, attitudinal, and behavioural traits) not favourable to some adherence activities; Particular patient social situations.</p> <p>Difficulties with technology</p> <p>Usability problems for elderly patients; Resistance to using cutting edge technologies and devices because of lower level of experience or familiarity; Attachment to older technologies; Lack of acceptance of complicated and un-robust devices and solutions.</p> <p>Interaction with devices</p> <p>Dilemma about the optimal combination of patient and technology activity; Patients bothered by ‘too much and too often’ interactions; Difficulty with limited input-output capabilities of mobile devices.</p> <p>Security and privacy</p> <p>Reluctance to communicate personal data through wireless channels.</p>
Institutions (health insurance and disease management)	<p>Improve patient health behaviour; Improve efficiency and effectiveness of outpatient care; Save healthcare system time and money.</p>	<p>Technology choice and implementation concerns; High investment costs; Contradiction between standardized practices and patient centeredness; Economies of scale and reaching a critical number of users.</p>
Government and society	<p>Alleviate the contradiction between the increasing demand for better healthcare and society’s limited resources; Reduce waste of resources; Redistribution of resources towards patients who need them most; Better managing chronic illnesses on a regular basis; People would live a quasi-normal and active life, thus not being a burden for society; Facilitate the modern tendency towards patient involvement in medical decisions.</p>	<p>Technology obstacles</p> <p>Need to use an open platform to facilitate collaboration with existing or future systems; Need to use a highly customizable technology; Need to address technology problems early in the design.</p> <p>Human barriers</p> <p>Alteration of existing homecare systems; Create, change, or cut jobs; Train people for support centres empowered by wireless capabilities; Face significant stakeholder resistance to change.</p>

Table 2. Mobile Solutions to Improve Outpatient Adherence: Healthcare Professionals' Motivators and Demotivators

Stakeholders	Motivators and Opportunities	Demotivators and Barriers
Healthcare professionals	<p>Foster close and continuous dialogue with outpatients;</p> <p>Improve outpatient active involvement in their own care;</p> <p>Decrease waste of professional resources;</p> <p>Shift professional workload from routine to quality interventions;</p> <p>Ease work of home care providers;</p> <p>Increase work satisfaction;</p> <p>Reduce frequency of patient complaints.</p>	<p><i>Outcome value</i></p> <p>Uncertainty regarding accuracy and reliability of adherence measuring;</p> <p>Incorrect understanding of the type and time of the expected results may induce mistrust.</p> <p><i>Reimbursement</i></p> <p>No mechanism to reimburse most physicians for the time spent to interact remotely with patients or patient data.</p> <p><i>Overwork</i></p> <p>Impossible to launch new healthcare initiatives that require more work;</p> <p>Risk of system overflow by patient-initiated synchronous communication demands;</p> <p>Badly designed or tuned systems might automatically launch too many false alarms about patient status.</p> <p><i>Work pattern changes</i></p> <p>Physician concerns about being removed from their current central roles of healthcare provision;</p> <p>Physicians still bear the liability for patient care although not paid for the extra time allotted to homecare services;</p> <p>Physician refusal to use technology because of a belief that it degrades their professional status, or because of technophobia;</p> <p>Homecare nurses have to trade social relations for technology-mediated ones;</p> <p>Training required by new technology.</p> <p><i>Medical issues</i></p> <p>Who bears the responsibility in case of misunderstandings due to temporary technology failures?</p> <p>Who would be legally responsible for third party advice from social groups facilitated by the technology?</p> <p>Patient data being made available to third parties in discussion groups.</p> <p><i>Security and privacy</i></p> <p>Uncertainty about best data storage approach: distributed or centralized;</p> <p>Insufficient privacy when patients communicate from public locations with healthcare professionals.</p>

Figures

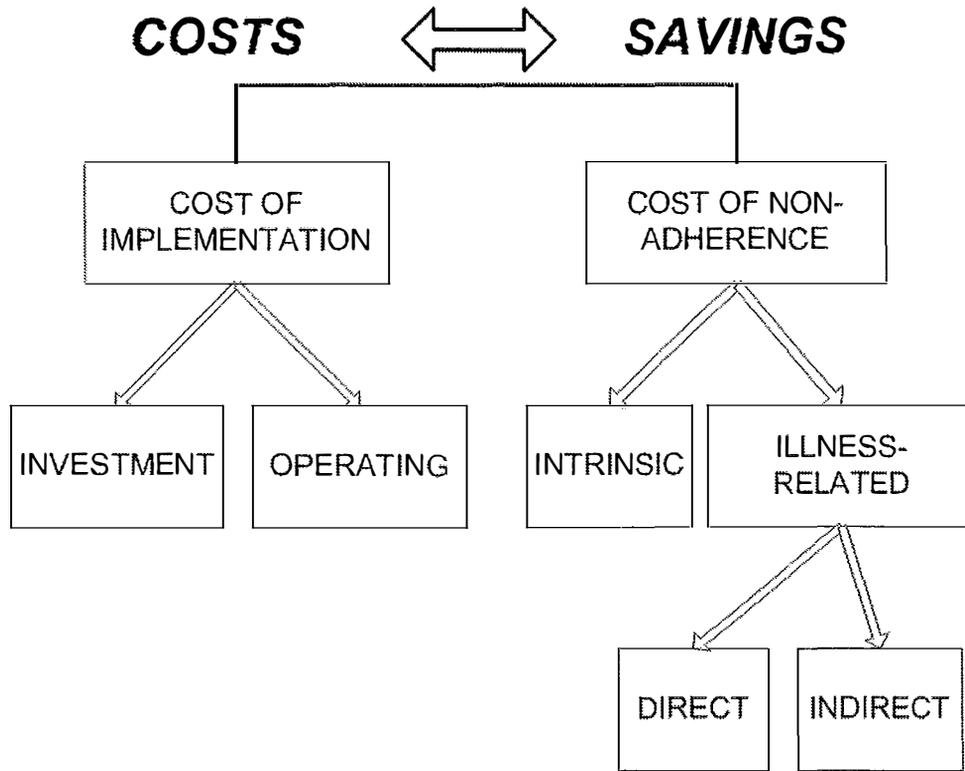
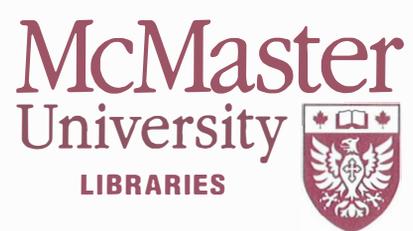


Figure 1. Costs and Savings from a Mobile Healthcare Initiative for Improving Outpatient Adherence

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