Using Personal Handheld Computing Devices for Personalizing Healthcare

A Contribution from the IMIA Working Group on Telehealth

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Summary

Objectives: Telehealth has an increasing role in future healthcare. This paper seeks to define and understand recent advances in provision of tele-healthcare through use of personal handheld computing devices, and suggests how such personalized solutions offer further opportunities for progress.

Methods: We considered the current status of personal handheld computing devices for personalizing healthcare, through review of examples in the literature and web sources.

Results: We have identified the following four generic roles for personal handheld computing devices in personalized healthcare: educational, social networking and games, monitoring with notifications/reminders, and online/offline tele-consultations. We discuss examples of these in two settings: healthcare facilities and patient home.

Conclusion: Advances in latest handheld computing devices have made tele-healthcare more personalized and increasingly possible even in the absence of the care provider.

Keywords

Personal handheld computing devices; personalizing healthcare, tele-healthcare, telehealth

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Introduction

"Managing personal health should be as easy as using an ATM machine." statement by U.S. Home Health Secretary Kathleen Sebelius (2009) [1].

With increase of average lifespan [2], there has been an increase in the incidence of chronic disorders [3;4]. This has increased the need for medical interventions [4;5]. Rising healthcare costs have meant that many of those affected have to learn to make do without actually visiting the doctor [6]. New groups of young patients and increased need for care among the increasing number of elderly imply new health care challenges. Along with this development we face decreasing care support from next-of-kin, volunteers as well as health-care personnel [7]. We also experience lack of coordination and integrated care as well as social isolation[8].

With the advent of the Internet and the ensuing information explosion, individuals are able to search and find information relevant to their own problem, and services which can help them to address that problem e.g. for common diseases such as diabetes [9;10]. This has been aided by recent increase in use of Internet access through personal handheld computing devices [11]. Easy access and possibility to search have even lead to occasional instances where the patient has access to more information about his problems and potential solutions than the healthcare provider [12].

This position paper attempts to provide an insight into how recent advances in computing devices, especially personal handheld computing devices (including tablet computers and smart mobile phones), can be used not only to provide self-intervention but also to provide healthcare from a distance.

Methodology

We have based our considerations on an ad hoc survey we made as a recent activity of the IMIA Working Group on Telehealth. We assessed the current status of *personal handheld computing devices* for use in *personalizing healthcare*, through free ranging search of recent (last 5 years) published literature and online web accessible sources, around the above six keywords. Our collaborative review of relevant and interesting use cases from this search exercise through online group discussion amongst the Working Group members, led us to classify and summarise this material to provide our view of the landscape presented below.

First we discuss our investigations and findings on how personal handheld computing devices are proposed to be used in novel ways in healthcare. Then we describe four generic roles in which these devices have begun to be used. Finally we consider two different example settings in which such usage might occur: healthcare facilities, where

the devices are used to support the provision of tele-healthcare, and in the patient home, where the devices can assist with personalized self-care and managed care. An actual use case example is showcased in the textbox below.

Generic Roles for Personal Handheld Computing Devices

Traditional roles for personal handheld computing devices were derived from steps in clinical workflow where these devices offered an alternative to the current mechanism for some form of information handling. For example, Personal Digital Assistants (PDAs) were seen as an enabler for Computerised Physician Order Entry (CPOE) from the bedside, while Computer on Wheels (COWs) were intended as a means to automate charting and access to electronic patient records. These older roles place such devices in the domain of physical tools for use by clinicians, rather than empowerment tools for patients or carers.

Within the last decade, two factors have changed in this arena. First, there has been considerable convergence between computation and telecommunications functions for these devices, providing powerful and highly connected tools in the hands of the consumer. It is no longer significant whether the device under consideration is a tablet computer or a smart mobile phone: the functionalities are comparable, and consequently the devices are interchangeable. Second, the disruption of normal healthcare processes by the advent of new models of care, has provoked the evolution of healthcare solutions by leveraging non-clinical opportunities, amongst them new technologies such as ICT. For instance, in some situations (e.g. the UK NHS [13]), patients are able to determine availability and book appointments online, without direct interaction with a physician's office or staff. Many of the emerging new models of care emphasize patient-cen-

tered or personalized healthcare, for which well established appropriate healthcare processes and services are yet to be developed.

Against this background some emerging trends can be observed. Personal handheld computing devices offer powerful new portal-style capabilities for accessing and managing information, to support various existing and new activities which are part of overall healthcare processes. They also provide mechanisms for delivery of new patient-centred healthcare activities, by virtue of their computational power and connectivity.

We have identified four specific new roles which exemplify these trends.

Educational role: delivery of information to the patients or clinicians in more meaningful and immediately useful ways, by making use of search and semantic interpretation capabilities. Rather than restricted access in library style systems to only a controlled body of literature (e.g. textbooks, clinical journals) as offered by conventional institutional computer systems, there is a much wider body of information content which can be accessed such as case histories and patient experiences [14]. The variety of media is also more varied: audio recordings, videos, animations and lectures can be readily sourced on a given topic.

Social networking and games role: to help improve the healthcare process by providing access to online sites for connections and information sharing between patients and other patients or carers, and to new social role-play and experiential environments where patients can more fully explore their health situation and plan its management. For example, many adolescents with Type 1 Diabetes Mellitus (T1DM) have a tendency to suppress the fact that they continuously need to take care of their disease, leading to long-term complications of T1DM emerging at a comparatively early age. Their awareness could be stimulated and adherence reinforced through peer support provided through social networking [15], or at-

titude influence through artificial personas generated in virtual world or computer game situations.

Monitoring with notifications/reminders role: Rather than monitoring of patients being confined to those using specialised medical devices within care facilities, personal handheld computing devices can be used to collect measurements and observations (e.g. motion, vital signs) and to deliver consequential time-based directives (e.g. alerts, medication prompts). The opportunity exists for gaining better and fuller information about the health status of patients, through mapping of activities of daily living, and establishment of patterns for good or bad health conditions [16], through processing of past data. These options can be backed up with human interventions such as personal carers or subscriber call centres.

Online/offline tele-consultation role: Availability of healthcare personnel at times of patient need can be enabled through telecommunications connectivity, to access a wider range of such personnel and means to communicate with them. These include online triage [17], oncall clinical support, remote consultations, ad hoc contact with case manager or nurse, interaction with broader care team members (e.g. family or community).

Example 1: Healthcare Facility Setting

New patterns of continuous communication can make healthcare more efficient and reduce visits because they:

- a) Enable all people to access their PHR data from their mobile phone. This will reduce medical errors, increase the quality of care, and reduce costs by reducing unnecessary tests and visits.
- b) Create systems that allow clinicians better access to resources (formularies, guidelines, policies, etc.) at the point-of-care.
- c) Encourage people to use Internet-

based solutions that can change their life style and keep them healthier through:

- i. Creating a better environment for point-of-care access to patient information and documentation [18] thus enabling clinicians to better documentation into the electronic medical record.
- ii. Implementing communication-based disease management for asthma, chronic obstructive pulmonary disease (COPD), diabetes [19], hypertension, smoke cessation [11], etc. to reduce emergency visits, thereby saving costs and improving the quality of care.

Through integration of smart mobile phones and net-based computing services, we may:

- a) Enable emergency responders to capture relevant health information of a patient electronically and sending it in advance to the emergency department. This may include the design of a region-wide record locator service in the event a patient's health data cannot be accessed from his or her phone [20].
- b) Combine information recorded by the patients with public health efforts by:
 - i. Automating selected reports from providers and patients on their progress in specific conditions that impact the public health, e.g., flu epidemics, HIV/AIDS, TB.
 - ii. Tapping into a wealth of information within the participatory health community.
 - iii. Establishing targeted disease surveillance within the region [16]. Designing and implementing systems that can notify people in case of health emergencies such as cases of bio-terrorism and natural disasters.
 - iii. On-line appointment systems to enable patients to identify which providers are available, when and where to make and change appointments etc.

Example 2: Patient Home Setting

New developments in information and telecommunication technologies deployed in the home setting hold much promise for improving health and wellness aspects in the lives of many [21]. We can distinguish several different categories of beneficiaries and their associated needs:

- a) Aged persons living independently or in partial assisted care, needing support or surveillance [22].
- a) People with chronic diseases needing to manage their condition.
- b) Post-operative or post-episode patients recovering at home, needing rehabilitation support.
- c) Persons in high risk categories, needing constant reinforcement of preventive measures.
- d) Healthy individuals who wish to maintain a proactive health maintenance lifestyle.

The recent proliferation of tablet computers (such as the i-Pad) provides us with a very appropriate platform on which to implement many user-friendly personal healthcare applications including various telehealth functions especially pertaining to chronic diseases [23; 24]. Its suitability arises from its highly ergonomic physical characteristics balancing portability with visibility, and a user-friendly tactile human-computer interface, which together with its broad range of data channels support good quality audio and video communications and ease of mobile phone or other wireless connectivity.

While it can be seen as replacing or complementing several other ICT devices which have made strong impacts in healthcare (e.g. mobile phone, personal digital assistant, laptop/netbook), the tablet is in itself a disruptive technology offering an unparalleled platform for integration of multiple user functionality in healthcare as well as new opportunities. One aspect of this disruption is its suitability for a variety of purposes leveraging the benefits of

telehealth. There are three main distinctive modes of applicability in which tablets are making inroads to personal healthcare as discussed below, and all of them may be associated with telehealth services or related eHealth interdependencies in some way.

Firstly, they can act as *collectors and aggregators of data* about the person of interest, which may be the basis of tele-monitoring health messages to a health status recording or a surveillance facility. A typical scenario for this mode is the logging of vital signs transmitted from small wearable devices which are limited in storage, processing ability and connectivity [25]. Another situation is the tracking of activities of daily living through information from ambient sensors in a "smart home" environment [26]. Harvesting of information in personal health records from the tablet could further enhance these processes through appropriate clinical decision support software.

Secondly, they can enable healthcare *communication and interaction* with external agents such as clinicians, professional caregivers, health call centres or extended non-clinical care team members (e.g. family and friends). Data gathering activities such as those described in the paragraph above may prompt human (or machine) intervention and communication via the tablet with the person of interest, to conduct a check on their health safety or to warn them of an impending high risk health condition. They may also be used for more routine interactions with clinicians in tele-consultations and transfer of related information such as digital images for store and forward processing. Interactions with groups of selected contacts and others in the wider community for sharing of health experiences and information can be easily supported (e.g. social networking). Thirdly, they can provide self-standing *access to healthcare support applications* both locally and on external systems. A major benefit of the passive nature of this mode is the capacity to boost morale and improve the quality

of life for those living independently [25] without the need for direct involvement of another person. This may still be viewed as telehealth in a virtual sense, if one allows for software to be regarded as an agent for healthcare delivery rather than a human. One use of this mode is to provide health information access and management functions such as management of personal health records, or participation in medication adherence programs [27]. Another use is to allow self-interventions for health maintenance and improvement purposes, such as physical activity monitoring, or cognitive and mental health exercises [28]. One of the major benefits of the passive nature of this mode is the capacity to boost morale and improve the quality of life for those living independently [29].

Discussion

A hospital is an environment to take care of the sick, however the individual would prefer to remain healthy. This shifting of focus from sickness care to wellness is of necessity creating a demand not only for methods which prevent sickness but also methods which promote selfcare at times of need [11]. While the concept of a personal health record or personal health informatics is a very Western developed concept, it may be applicable to other areas, too, as most populations especially in urban areas are approaching health care levels similar to the West [30].

On the other hand, despite a rise in mobile connectivity [31], it is also the case that very few people in the developing world have access to the internet or possess smart phones [26]. In the developing world, the battle still is to manage sickness before wellness. Also, telemedicine applications are not yet integrated into electronic health records and as the existence of EMRs/EHRs is poor [32]. In some countries, another problem might be that the current legislation does not allow integrated solu-

A.J., a 25 year old male was pouring boiling water into a kettle to take steam inhalation for his cold, based on a reading of Wikipedia. The hot water spilled onto his leg and resulted in a scalding sensation. Even while he was removing the hot clothes, he immediately searched Google on his Android enabled phone to know what to do next.

He got the answer and started pouring cold water to cool the area where he felt the pain. He contacted his doctor who asked him to apply Silver Sulphadiazine. While going to the pharmacist to purchase Silver Sulfadiazine cream and pain killers, he sent the photo of his blister even while it was erupting (Figure 1). The doctor gave an appointment for the next day, when the blister was punctured but he was already feeling better.

Five days later, the burn had healed. This was confirmed by a photo sent to the surgeon (Figure 2) from the same mobile.

Fig. 1 Photo sent around an hour after burn

Fig. 2 Healed in 5 days due to prompt self care and Internet

tions. Costs of the more sophisticated handheld devices and their safety in user settings of developing countries raise additional issues.

Handheld devices are being used for personal healthcare provision and the use is rising but this widespread use does have possible problems, including:

- Open information may be without evidence, incorrect and may even be harmful.
- Most machine-based systems do not anticipate or correct uncommon problems. Widespread use would underly the need for even more personalized decision support systems as apposed to the applications available today. However, costs would be a limiting factor.
- Most advances are introduced into the market without adequate testing. This underlies a need for an

FDA type approval for informatics solutions.

- The available solutions are of a huge number with variations not only of the manufacturer, the operating system, but also in the overall quality. Choosing the application which one needs to use may be a problem.
- Since the end user is more likely to be healthcare professional, his needs are fairly complex. This has lead to a mismatch of user requirements and available solutions.
- Some problems specific for smart devices being used for mHealth are
 - a. Smart phones are costlier than simpler devices. Most applications need a compatible device. Good outcomes have been reported when compatible phones are provided by the employer [16] but this is not always the case.

- b. The small screen makes clarity or availability of a comprehensive view a limiting factor.
- c. Finally, touch screens do have a "getting used to" factor which is all the more important as most chronic disease incidence occurs in aged persons, who may not be able to adapt easily or quickly to rapid changes in technology.

Conclusion

Advances in the latest handheld computing devices have made telehealthcare more personalized and increasingly possible even in the absence of the care provider. The use of such devices has become increasingly more complex, in the sense that it is used to display important status information as well as function as a communication gateway to healthcare providers. For example, in diabetes treatment, handheld computing devices are expected to play a key role in the forthcoming automated closed loop control, known as an "artificial pancreas" [33]. The areas identified in this paper are seen as popular "forerunners" which will no doubt sustain much more development in the next few years. An interesting and open question is what other areas of usage will emerge, as the personalization of computing in society grows and influences what might be adoptable to provide new ways to realize benefits in healthcare.

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