TABLET COMPUTERS FOR mHEALTH:
OPPORTUNITIES FOR PERSONAL HEALTHCARE

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ABSTRACT
Recent information and telecommunication technologies innovations offer many opportunities for health and wellness interventions to be deployed in non-traditional care settings. This paper considers some modes of applicability for which tablet computers would be particularly well suited, and recommends incorporating them appropriately into mainstream personal healthcare to support healthcare reform changes. These applications would potentially be applicable in a wide range of different healthcare environments and settings.

KEY WORDS
mHealth, telehealth, tablet computer, personal healthcare

1. Introduction
Healthcare reform has become a major theme of health systems evolution and change in recent years. The concepts of “new models of care” and “patient-centred healthcare” are two aspects of reform where information and communication technologies (ICT) can contribute and may even drive change. Within the ICT domain, the proliferation of personal communication devices such as mobile phones has had a strong impact on healthcare in terms of connectivity, leading to many new developments in mHealth, but has made few inroads on healthcare tasks with computational demands. We argue here that there are some other applications which deserve consideration on this computational end of the spectrum.

In this paper we are concerned with establishing a nexus between two areas of interest: tablet computers and personal healthcare. Both are recent developments, in the technological and clinical domains respectively. Both leverage a continuing societal trend to “offload” and “personalise” activities of life, moving the focus of control and responsibility towards the individual. In settings where individuals have traditionally been underempowered, or economic and cultural pressures limit innovation, such developments can be contentious and disruptive, and consequently implementation and adoption can be slower. However, if the technology rapidly becomes ubiquitous and its penetration is pervasive through the community, pressure for change and infusion of the related functionality offered by the new technology is still realistically achievable.

Here we will argue that for niche applications where new opportunities for uptake can be generated, deployment of tablet computers for personal healthcare is an attractive option. In making this claim, we do not differentiate between high income countries, where sophisticated healthcare systems are already in place, or low and middle income countries where many inadequacies exist, in determining the appropriateness of the technology being advocated. The tablet computer may be seen in a similar light to the mobile phone, which provided a “leapfrog” technology opportunity for many countries which lacked widespread conventional wired telecommunications infrastructure. While it may be seen as a new and expensive device in the market today, it is intrinsically suited for the low price end of the mass consumer ICT range and is already trending towards price compatibility with mobile phones.

2. Personal Healthcare
Personal healthcare here refers to patient-centred elements of healthcare for which the patient takes responsibility and control, in order to pursue them proactively [1]. It contrasts with the usual view of healthcare as a system with subsystems for primary, community and acute care. The emergence of personal healthcare in the past decade has been focussed mainly on home telehealth activities such as virtual visits and vital signs measurement [2]. Contemporary growth of mHealth environments based on mobile phone technology have extended the scope to apply independently of location “ubiquitously” or “pervasively” [3] and to include other patient-oriented services such as remote access to health records and web based educational facilities and health promotion information [4]. A more recent development is the concept of an integrated health and wellness environment with ambient intelligence to support non-traditional care settings, such as the home [5] or arbitrary care locations such as during travel [6].

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We can distinguish several different categories of potential beneficiaries of personal healthcare advances, and identify their associated needs:

- Aged persons living independently or in partial assisted care, needing support or surveillance
- Chronic disease sufferers over broad age/health range, needing to manage their condition
- Post-operative or post-episode patients recovering at home, needing rehabilitation support and daily activities monitoring
- Persons in high risk categories, needing constant reinforcement of preventative measures and medication adherence
- Peri-natal and maternal care, including paediatrics and infant/child health
- Healthy individuals who wish to maintain a proactive health maintenance lifestyle
- A broad spectrum of users wishing to source health advice and manage personal health data.

This is a wide spread of beneficiaries, some of whom will be more capable and have more compelling reasons than others to adopt assistive technologies as part of their personal healthcare solution. If the technology permits easy, fast and intuitive consumer use, there is greater prospect that it may benefit several categories within this range. In addition, it should be anticipated that the new technology based healthcare solutions will provide users with mechanisms for self-care, rather than merely increasing channels of communication with healthcare professionals (such as phone calls and emails) and thereby adding to their already saturated workload.

The personal healthcare needs associated with the above diverse categories of patient can be identified as:

- Communicating as humans with carers and other health service providers (e.g. call centre enquiries)
- Providing data related to their healthcare and health status back to the health system (e.g. activity measures)
- Using tools for self-assessment and decision making for their healthcare actions (e.g. asthma severity)
- Finding resources and information about their health condition (e.g. physical activity)
- Accessing and maintaining their health records and related content (e.g. episode summaries).

These functions are quite varied and a technology based solution would need to be flexible and simple to allow easy implementation of solutions across this range. Below we will consider the capabilities of tablet computers that will help to address the various beneficiary needs, by provision of such functions.

3. Tablet Computers

The recent proliferation of the tablet computer provides us with a very appropriate platform on which to implement many user-friendly personal healthcare applications including various telehealth functions. Its suitability arises from its highly ergonomic physical characteristics balancing portability with visibility, and a user-friendly tactile human-computer interface which allows simple interactive touch control. This benign user environment, together with wide range of data channels, support good quality audio and video communications and ease of mobile phone or other wireless connectivity.

Some of these aspects are shared with the smartphone which has come to be regarded as the conventional delivery device for mHealth, but it imposes considerable limitations of size (for both viewing and touching) and processing power in exchange for affordability and convenience. While the tablet computer can be seen on one hand as replacing or complementing several other ICT devices which have made strong impacts in healthcare (e.g. mobile phone, personal digital assistant, laptop/netbook, personal/desktop computer), it should also be recognised as a new disruptive technology offering an appropriate platform for integration of multiple user functions in healthcare as well as new opportunities to create new functions.

One major aspect of the technological disruption associated with the tablet computer is its suitability for a variety of purposes involving individual empowerment, to a greater extent than the widely promoted benefits of mobile phones for delivering mHealth. These purposes include reinforcement feedback based “patient-in-the-loop” approaches to healthcare (where a cycle of interactions occurs between patient and carers), and self-managed personally controlled healthcare activities (where the patient relies primarily on computer based interactions, supported by occasional contacts with healthcare professionals).
Table 1: Comparison of various competing technologies for delivery of personal healthcare

<table>
<thead>
<tr>
<th></th>
<th>Mobile phone (voice/SMS)</th>
<th>Smart phone (internet/web)</th>
<th>Personal digital assistant</th>
<th>Tablet computer</th>
<th>Laptop computer</th>
<th>Desktop computer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>Low</td>
<td>Mid</td>
<td>Mid</td>
<td>Mid</td>
<td>High</td>
<td>High</td>
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<tr>
<td>Portability</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Mid</td>
<td>Low</td>
</tr>
<tr>
<td>Useability</td>
<td>Mid</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Mid</td>
<td>Mid</td>
</tr>
<tr>
<td>Connectivity</td>
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<td>Low</td>
<td>High</td>
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<td>Compute power</td>
<td>Low</td>
<td>Mid</td>
<td>Mid</td>
<td>High</td>
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<tr>
<td>System Flexibility</td>
<td>Low</td>
<td>Mid</td>
<td>Low</td>
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</table>

These empowerment situations take advantage of three distinctive ICT physical characteristics of the tablet computer:

- local processing and storage capacity comparable with other conventional laptop or desktop computers, avoiding client-server mode of operation
- simple user environment without complex operating system functions and with more natural user interface through icons and touch screen, and native audio/video
- wireless telecommunications connectivity comparable with mobile and smart phones, avoiding a need to be networked as with conventional computers.

In addition, ease of portability and non-necessity of peripheral components (such as keyboard and mouse) and the ability to use “apps” as well as onboard software make the tablet computer more flexible than any of its abovementioned competitor technologies. A brief summary of how these devices compare qualitatively as competing technologies is given in Table 1.

4. Modes of Applicability

There are three main distinctive modes of applicability in which tablets are currently making inroads to personal healthcare as discussed below, and all of them may be associated with emerging telehealth services (or the 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 telemonitoring health messages to a health status recording or 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 [7]. Another situation is the tracking of activities of daily living through information from ambient sensors in a “smart home” environment [8]. 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 carers, health call centres or extended non-clinical careteam members (e.g. family and friends) [9]. Knowledge of the health status of the aged can be used to support their living independently [10]. Data gathering activities such as those described 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 teleconsultations 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 [11] 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 [12]. Another use is to allow self-interventions for health maintenance and improvement purposes, such as physical activity monitoring, or cognitive and mental health exercises [13].
5. Application Examples

In this section we will present 3 examples of opportunities for use of tablet computers in personal healthcare applications. In each case these are extensions based on existing common applications which are more modest in scope due to the limitations of their favoured existing implementation platform. We will describe the additional functionality that each application might embrace, which leverages the properties of the tablet computer.

5.1 Health Decision Support

Conventional ambient assisted living systems for supporting personal healthcare self-management for elderly individuals or chronic disease sufferers consist of personal monitoring devices and associated software (including apps) which can aggregate data (e.g. daily/weekly/monthly datasets) and provide simplistic feedback and visual displays (e.g. graphical or traffic light) to a user via telecare station or computer linked to a television set. A tablet computer allows more complex and visually sophisticated implementation of these functions. A backend decision support system which inspects the data and applies overall trend analysis and threshold detection, can then annotate the data to provide additional benefit through highlighting of warnings for anomalous situations. Machine learning capabilities can allow detection of repeated patterns and trend analysis for longer term behavioural and health status variations.

An ideal application would be the self-management for early stage chronic diseases like diabetes, cardiovascular or respiratory conditions. Variations in adherence to and response can occur in conjunction with living and lifestyle situations (e.g. eating habits for diabetes, physical activity for cardiovascular, and pollutants/allergens for respiratory). Engagement of the user beyond mere passive viewing of data will help to address such potentially adverse situations earlier and more successfully. The highly portable and large, clear display surface of the tablet computer, unencumbered by the distractions of separate processor and keyboard components, provides a concentrated attention channel for the human visual system. This allows for partitioning the screen functionally, for instance into an area for conventional visual presentation of data, and a pattern feedback area for alerting and informing the user for an exceptional situation. This latter area could also be populated with interactively accessed software tools, allowing them to query the system for guidance, conduct assessments and modelling, and retrieve educational material to help increase user understanding and “buy-in”.

5.2 Careteam Integration

Individuals who have advanced stage chronic diseases or multiple co-morbidities are typically managed according to a custom personalised careplan, often with multiple persons involved in their personal careteam. Ownership of the careplan often resides with a particular health service provider who is responsible for storing the patient electronic health record and reviewing and revising the careplan, and so typically it is difficult for careteam members to access and share it dynamically. Instead they often rely on abstracted summary or snapshot information pushed to them. This places limitations on the approaches used by the careteam members and the quality of their interactions with the patient, and leaves the patient uninformed and unempowered.

A computer tablet user environment allows the current careplan version and summary electronic health records to be downloaded easily in an “apps” or web based setting, for the patient to make use of by applying local software for analysis and display, while still being able to be maintained remotely in a central location if desired. Carers working with the patient can also use the tablet to update the electronic health record instantly, and gain access to tools (e.g. reference data, checklists, decision flowcharts) needed for delivering their particular care functions. In addition, the patient can use the tablet computer to communicate more meaningfully with carers or a broader support group, in single or multiparty audio-and video-conferencing scenarios and using electronic media (e.g. chat, blog, email). Additionally, personalised support functions such as cognitive assessments and medication reminders could be provided.

5.3 Personal Health Advisor

Preventative health and wellness programmes often rely on recording of data (e.g. daily nutritional and physical activity logging), prompting the provision of reinforcement feedback (e.g. charts of fitness progress) and educational information (e.g. hints on beneficial lifestyle practices) by the controlling software, accessed over the internet at a host website. These programmes usually consist of a static solution with a fixed set of options and responses, which may be revised and reloaded from time to time. User adherence to programmes is correspondingly lower than for human engagement where an element of encouragement is imparted by personal alignment of the interactions. Often a human “health coach” is retained to assist.

A tablet computer solution would allow more animated interaction with the user, exploiting the touchscreen and video capabilities to achieve a higher level of attentional saturation. Social media can be employed to provide
multiple human interactions and contact with multiple
users to create a support network which can mutually
reinforce through performance comparisons and
challenges, treating the preventative health activities as
social rather than clinical. An automated coaching or
advisory surrogate presence can be provided for routine
interactions of the system with the user, which can adapt
and evolve so that it presents different patterns of
behaviour to emulate personal human-like engagement.
For instance, an avatar could be used for delivery of daily
goal-setting and reminder or persuasion functions.

6. Conclusion

Personal healthcare applications for the tablet computer,
such as those described above, can offer significant
advantages over alternative ICT environments such as
laptop/desktop computers or mobile/smart phones. The
advantages arise from leveraging the special technical
and ergonomic features of this technology to provide a
richer user environment with greater utility, functionality
and useability. The tablet computer offers an integration
of features of both environments, while achieving a light
physical footprint. These factors allow applications to
create a personalized user environment, which attracts
higher levels of engagement and satisfaction from users.
While intuitive user appeal of such applications in non-
healthcare settings is apparent in everyday life, it remains
to establish their clinical effectiveness on the types of
healthcare scenarios described above, through
appropriate studies and trials.

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