Wireless Portable Devices in
Cancer Care Ontario

A Research and Pilot Program Report

For McMaster University MBA Independent Research Project

December 2002

Alex Drossos

For Prof. Milena Head

Abstract reviewed and accepted for presentation
at the COACH/CIHI e-Health Conference
in Toronto, Ontario on May 26th, 2003

Executive Summary

From July to December of 2002 the Hamilton Regional Cancer Centre undertook a research and pilot investigation of the use of wireless portable and handheld devices. The study's focus was on researching the current state of wireless technology and wireless enabled devices and then choosing a subset of these technologies and devices to test in a regional cancer centre setting in Hamilton. Explicit in the study description was to test both internal (i.e. WLAN) as well as external (i.e. WWAN through a wireless ISP) access. Furthermore it was our aim to test a variety of platforms and device types in order to be able to broadly apply our recommendations. It was not the intent of this study to embark on any software development. All software tested was commercially developed.

In general, the following items were included as components of the study:

1. Perform secondary research to determine the successes and failures of others' experiences with wireless portable devices;
2. Conduct a survey questionnaire of CCO staff across the province, but focusing on HRCC employees, to establish the need and desire for wireless access;
3. Begin a pilot program using wireless portable devices at HRCC and get feedback from the pilot program users;
4. Complete a cost-benefit analysis for longer-term use of wireless portable devices at CCO; and
5. Make recommendations on the types of devices and network topology that should be used based on local applications and need.

The results of each of these are discussed in turn below.

<u>Secondary Research</u>

The use of handheld devices is increasingly becoming more prevalent in health care and indeed by physicians. Current studies show that up to 85% of physicians would be willing to use a handheld device. In Canada today 28% of physicians use a PDA. This is up 47% over 2001. Male physicians and medical and surgical specialists are more likely to use PDAs over females and GPs respectively. Perhaps the biggest way in which PDAs are proliferating into the physician arena is through the MD University training

programs. Many schools are now requiring their medical students to use PDAs (typically Palm based devices) as part of their training.

We also know however that PDAs are not always the optimal device for physicians beyond accessing e-mail, personal information management applications (PIM, including calendar, contacts, tasks and notes) and medical reference material. There are many situations when a physician or other clinician requires a larger screen size and resolution, easier input method (over “graffiti” or similar input method for PDAs) and better memory capabilities. For such situations, these factors outweigh the benefits of PDAs: high portability, small size and weight, instant on ability and robustness. The challenge is finding a device that meets the additional requirements not met by a PDA but that is still portable and preferably “handheld” at leas to a certain degree.

To this end Tablet Computers (or Tablet PCs) fit the description quite well. They still have the limitations of shorter battery life and, sometimes, weight but overall they are a good compromise between the PDA and the lap top computer. Unfortunately one problem faced by using Tablet PCs is that the majority of them today are now using the new Microsoft Tablet PC operating system which is a superset of the Windows XP Professional OS. This is a problem for CCO since today Windows XP is not a supported operating system and in fact many clinical applications are not functional on Windows XP. Fortunately there are Tablet PCs available that work on other versions of Windows as well; they are less prevalent and slightly more difficult to find however.

Hardwired networks have always created an obstacle for healthcare clinicians. The physical and geographic limitations of computing devices has meant that adoption of some technologies has proceeded at a rate slower than needed or desired in the health care industry. With wireless technologies such as the IEEE 802.11b, 802.11a, and 802.15 (Bluetooth) becoming standardized some of these limitations can be removed. Unlike many technologies introduced in healthcare, wireless technologies have a high acceptance rate among physicians and other clinicians. Although wireless technologies may not quite be considered a panacea they are definitely having a large impact on care delivery. This study limited *internal* testing to the 802.11b wireless format, which is currently the most established. 802.11b has numerous concerns in terms of security. Effectively, WEP encryption and MAC addressing schemes are not sufficient to secure an 802.11b wireless network; further security methods must be used such as VPN authentication, Leap (on Cisco devices), etc. Some of these security and

encryption methods can also be used for cellular technologies such as GSM/GPRS and CDMA2000 (or 1xRTT) which were tested for *external* wireless access.

One consideration of note for wireless networks is the potential biomedical interference that may be caused by the RF waves that are transmitting data in the cancer centre. For 802.11b this is not a problem since this network operates at the 2.4 GHz band which doesn't interfere with (effectively) any medical equipment. This may not be the case with the GSM/GPRS and CDMA2000 technologies however, which is why these wireless technologies should be limited to use outside of cancer centres and hospitals.

The current context of CCO, especially in terms of hospital and regional integration and the recently released Information Management strategy, perhaps makes the timing of this study seem odd. However, this study simply aimed to provide other cancer centres with data and information on how wireless portable devices can be used in an outpatient clinical oncology setting regardless of under whose jurisdiction this falls.

Survey Questionnaire

The results of the survey questionnaire were very promising. The survey was conducted in early November. An e-mail invitation to participate was sent out to all HRCC staff and selected staff from all other regional cancer centres and the CCO provincial office. The groups who received the invitation at non-HRCC locations consisted mostly of physicians (and some other clinicians), researchers, senior management and information technology staff. A total of 129 responses were received, 87 of which were from the HRCC. The rest of the responses were more or less evenly received from the other regional cancer centres and the provincial office. Exceptions included: 1 response from LRCC, 2 responses from WRCC and 13 responses from TSRCC. All other cancer centres had an average of 5 respondents. Therefore caution should be exercised in applying the results of the survey to other cancer centres beyond HRCC.

Of all the respondents, 59% were females and 80% were between the ages of 30-49 (the latter were counted as the merger of the 30-39 and 40-49 age categories collected in the survey). Interestingly, of the respondents, 60% considered themselves to be average computer users while an additional 28% considered themselves advanced users. The remainder marked novice or power user as the appropriate level for computer use. A full 96 (74%) currently use a pager; another 95 (74%) currently use a cell phone;

72 of the respondents use a lap top (56%); 48 use PDAs (37%); and only 8 (6%) don't use any of the above. Of all respondents, 102 or 79% use at least two of the above devices, 57 (44%) use at least three of the devices, and 31 (24%) use all four devices. 85% of the survey participants use the devices for either clinical/business use (26 respondents) or both clinical/business and personal use (84 respondents).

In terms of current use on desktop PCs, the respondents ranked the following applications as the five most used:

1. Exchange (or Lotus Notes)
2. Web Browser
3. Word
4. OPIS
5. PowerPoint

When asked to rank the same applications in priority order if they could select only three for wireless access the list became:

1. Exchange (or Lotus Notes)
2. OPIS
3. Web Browser

The following table outlines the number of respondents who answered "Yes", "Somewhat" and "No" to the usefulness of secure wireless network access within the cancer centre and outside of the cancer centre. In general, there was little correlation between computer competence level and a desire for wireless access (within or outside the centre).

Access Within	Number Answered	Access Outside	Number Answered
Yes	60	Yes	70
Somewhat	48	Somewhat	34
No	21	No	25

The remainder of the survey results shown below focus on the target group consisting of physicians, research/clinical trials, and senior management staff (45% of all respondents). However the 10 respondents that were research/clinical trials staff were all from HRCC; therefore these individuals were left out of the following summary results.

This target group ranked the top three applications for wireless access the same way as the entire respondent pool did. An exception is seen if the senior management group is looked at separately. This group ranked Word as the second most important application instead of OPIS. The third ranked application (web browser) was unaffected

by the different second rank choice. The results of asking to establish the usefulness of wireless access within and outside the cancer centre (or work location) were very clear for the target group. Only 3 (6%) answered “No” to the wireless access within the centre and 5 (10%) answered “No” to wireless access outside the centre. A full 65% (or 31 respondents) answered “Yes” to wireless access within the centre and 69% (33) to wireless access outside of the centre.

Access Within	Number Answered	Access Outside	Number Answered
Yes	31	Yes	33
Somewhat	14	Somewhat	10
No	3	No	5

Pilot Program

The pilot program consisted of testing the following three devices in a clinical or business setting at the HRCC:

1. Handspring Treo 180 SmartPhone form factor with Palm OS, monochrome screen, and GSM/GPRS wireless access externally on the Rogers AT&T network.
2. Compaq iPAQ 3800/3900 PDA form factor with Windows CE Pocket PC 2002 operating system, colour screen, and 802.11b WLAN access internally and CDMA2000 WWAN access externally on the Bell Mobility network.
3. Acer Travelmate TM C102Ti mini-“convertible” Tablet PC form factor with Windows XP Tablet PC Edition operating system, high-resolution colour screen, and built-in 802.11b WLAN access internally and CDMA2000 WWAN access externally on the Bell Mobility network.

Since full details of the findings for each individual device cannot reasonably be included here, a point form summary of the findings is included instead. Furthermore, the pilot program is still ongoing so some of the findings are still unclear at this time.

- Wireless technologies have a high acceptance rate among health care practitioners and truly have the ability to greatly impact patient care and workflow processes in a positive manner.
- Wireless network security is paramount to success. VPN configuration on handheld devices (both Palm and Windows based) is not trivial.
- Device choice should be need based. This decision should also be made with the workflow process(es), application(s) and user(s) in mind.

- Stable and established technology is often better to use than the "latest and greatest" available.
- Battery life and true portability are large factors in determining clinician buy-in.
- Initial training and ongoing support are required for wireless networks and portable devices and the expertise for these must exist in-house. As with all new technology it takes users some time to feel comfortable with using wireless and portable devices.
- For general application access the preferred device type is a large form factor such as a tablet computer or lap top with wireless functionality.
- PDAs are suitable for specific applications that are appropriate for the size and resolution of the screen.
- The SmartPhone form factor is highly portable and integrated. It is not very useful for a clinical setting, but is extremely useful for management staff who are on the road frequently and need to stay connected.

The anecdote below, which is from one of the physician pilot program users at the HRCC, has been included to give a sense of the potential impact of this technology:

> *The furtherance of such technology is the wave of the future. Access to clinical information while in the patient examination room is important - having to go out into the clinic conference room to look up information can be sometimes disruptive. In addition, having a computer unfettered by wiring more than makes up for the lack of computers in the examination rooms.*

Cost-Benefit Analysis

The cost-benefit analysis was conducted at a high level. A separate cost-benefit analysis was conducted for each of the three tested devices. The analysis also focused on the actual costs rather than opportunity costs since the latter are difficult to analyze and quantify in the CCO environment. Furthermore, support, training, maintenance, and upgrade costs were not included in the calculations.

The first year costs for the Handspring Treo 180 (with full wireless functionality), including hardware, software and air time, were estimated at $2,400. Each year thereafter would cost about $1,300 for the ongoing services. In terms of comparison to the status quo (i.e. someone who currently uses a Palm device, a cell phone and a pager) the first year costs are approximately $1,620 and the ongoing annual costs are

$960. Therefore the initial costs are the most substantial but even in terms of ongoing costs the Treo is higher than the current situation.

Total first year costs for a Compaq iPAQ 3900 with WLAN and WWAN cards and required accessories, as well as wireless ISP network air time are $2,450. This figure is very close to that of the Handspring Treo. The ongoing costs for the iPAQ are low at only $600. If only internal (i.e. WLAN) access is desired, these costs reduce to $1,250 and $0 respectively. Remember that support, training, maintenance and upgrade costs are not included. Since a current "status quo" is not easily available for this device a comparison was not made.

For the Acer Tablet PC with WLAN and WWAN access the costs are $5,000 and $600 respectively for first year and ongoing costs. These change to $3,800 and $0 when the WWAN access is removed from the equation. In order to perform a comparison of the latter situation to the status quo a lap top with WLAN card was used. The first year and ongoing costs for this scenario are approximately $2,500 and $0 respectively.

Recommendations

The recommendations resulting from this study for RCCs that are interested in pursuing deploying wireless portable devices are listed below. Many of these have been discussed previously in this document but are summarized below for convenience.

General recommendations:

1. Before proceeding with deploying wireless portable devices a local evaluation of the need should be conducted to include the type of access (i.e. internal or external) and the types of devices and applications.
2. Clinician/user buy-in must be achieved for success. Ensure that the users are involved in the process during the design phase.
3. Some in-house expertise is highly recommended for such an endeavour.
4. Applications such as Web OPIS need to be further developed to increase functionality and to be designed with the portable device form factor in mind. A slightly different version for each form factor used may be required.
5. Physical security of portable devices can be challenging. PDA sized devices can especially easily go missing or get stolen.

6. Short battery life of wireless portable devices can quite possibly lead to failure of a wireless initiative. All possible alternatives to extend battery life to 'full shift lengths of time' should be considered.

Wireless Technologies specific recommendations:

7. Wireless network security and user authentication must be at the heart of your technology model. Wireless access point hardware must be carefully selected and placed to meet strict wireless security standards.
8. The IEEE 802.11b WLAN wireless network standard is stable and proven. It does however have security vulnerabilities. For the time being it is the wireless standard of choice, but as the IEEE 802.11a protocol standardizes further it should be fully evaluated and tested as well.
9. Cellular WWAN 2.5 and 3 G (generation) technologies are now very prevalent. With CDMA2000 technology likely surpassing that of GSM/GPRS it is the more recommended technology at this time. However GSM will continue to have the benefit of being the more globally used standard.
10. Internal wireless access is appropriate for all RCCs. External wireless access is likely more appropriate for centres where physicians and senior management staff travel frequently and long distances. Prime examples of this would be the NWORCC and NEORCC (assuming availability of wireless network access in Northern Ontario).

Portable Devices specific recommendations:

11. It is not possible to recommend a specific device for all uses and applications in the Regional Cancer Centre environment. Rather, choosing a device should be based on specific needs and requirements.
12. The Handspring Treo, or a similar device, should be used by senior management type staff in order to integrate numerous devices that are currently used. Wireless Internet and e-mail is for those individuals who need to stay connected.
13. The Compaq iPAQ, or a similar device, should be used predominantly for internal wireless access for applications specifically designed for that form factor. It can also be used for PIM and e-mail access.
14. The Acer Travelmate should not be used in a production setting since the Windows XP operating system is not currently supported for numerous clinical

applications. Tablet devices with internal wireless access using earlier versions of the Windows operating system are however very appropriate for use in clinics, the chemo suite, pharmacy, rads review, etc. Lap tops may be more appropriate for certain situations. Tablets and/or lap tops with external wireless access (i.e. WWAN) are recommended for physicians who require access on the road, for instance when traveling to outreach clinics at far distances.

Operating Systems specific recommendations:

15. As with recommending devices, one single operating system cannot be recommended to meet the needs of all users, uses and applications.
16. The Palm operating system is the 'gold standard' when it comes to PDAs. The ease of use, minimum resource requirements, low cost and extensive availability of software make it the PDA operating system of choice for individual or personal use of devices as well as for personal information management (PIM).
17. Windows CE based operating systems (including the Pocket PC 2002 edition on the Compaq iPAQ) have specific benefits. They have the look and feel of Windows with considerably lower resource requirements. Furthermore, Windows CE can be used in PDA type devices as well as Tablets. Software development is more straightforward for the Windows CE platform as compared to the Palm platform and therefore is the recommended platform when application development is required. Windows CE based devices should be used when they are for 'group' use as opposed to 'individual' use.
18. Traditional PC based Windows operating systems are most familiar for end users. They are effectively required for full-fledged portable computers including lap tops and tablet PCs.

Acknowledgements

The work reported herein would not have been possible without the project sponsorship of Patrick Baldwin, Manager of Information Technology at the Hamilton Regional Cancer Centre (HRCC), and the technical support of Gary Green, Network Specialist at HRCC. I would like to further thank the individuals who offered to pilot test the portable devices at HRCC, namely Dr. Andrew Arnold and Dr. Ian Dayes. Final words of thanks go to Dr. Milena Head, Assistant Professor McMaster University Michael G. DeGroote School of Business, and Director, MeRC (McMaster eBusiness Research Centre), who provided ongoing support and input to this report.

Brief Bio of Alex Drossos

Alex Drossos is a Decision Support Analyst with Cancer Care Ontario (CCO) in Toronto, Ontario. He will be graduating with a Master of Business Administration degree in Health Services Management from McMaster University in June 2003. Previous to this graduate level degree Alex completed degrees in Computer Engineering and Biology from the University of Western Ontario. Alex's current work at CCO involves the design and deployment of Business Intelligence software, data analysis, leading wireless initiatives and project management. He also has strong interests in health policy, health economics, e-health and ICTs, telehealth, technology assessment, privacy and security, aboriginal health, health prevention, fitness and nutrition, alternative therapies and pre-hospital care.

Apart from his full-time work, Alex volunteers extensively with a Canadian charity known as ACERT, which strives to advance pre-hospital care on post-secondary campuses. He has served as a Board member, Board Chair and is a past President of ACERT. Alex is also an Aerobic Fitness instructor and a Personal Trainer and especially enjoys sports conditioning and boxing regimens.

Table of Contents

Chapter 1: Introduction

Hardwired networks have always created an obstacle for healthcare clinicians. The physical and geographic limitations of computing devices has meant that adoption of some technologies has proceeded at a rate slower than needed or desired in the health care industry. With wireless technologies such as the IEEE 802.11b, 802.11a, and 802.15 (Bluetooth) becoming standardized some of these limitations can be removed. Unlike many technologies introduced in healthcare, wireless technologies have a high acceptance rate among physicians and other clinicians. Although wireless technologies may not quite be considered a panacea they are definitely having a large impact on care delivery.

Through this research and pilot program assessment at Cancer Care Ontario's (CCO) Hamilton Regional Cancer Centre (HRCC) an evaluation of the true efficacy and need for wireless networks and devices was made. It was the aim of this study to:

1. Perform secondary research to determine the successes and failures of others' experiences with wireless portable devices;
2. Conduct a survey questionnaire of CCO staff across the province, but focusing on HRCC employees, to establish the need and desire for wireless access;
3. Begin a pilot program using wireless portable devices at HRCC and get feedback from the pilot program users;
4. Complete a cost-benefit analysis for longer-term use of wireless portable devices at CCO; and
5. Make recommendations on the types of devices and network topology that should be used based on local applications and need.

The fifth item above assumes of course that the end result of the first four items is a positive one and indeed regional cancer centres should proceed with deploying wireless networks and devices. This report explains the details and results of each of the five aims of the study.

Chapter 2: Literature Review

(a) Portable Devices and the Wireless Web

Personal Digital Assistants (PDAs), or handheld computing devices, have become widespread in North American techno-culture, especially as portable enterprise computing solutions. They predominantly have been used for personal information management (PIM), but as the technology has improved so have their uses. PDAs are now used for document viewing (and editing and creation on a more limited basis), expense tracking, and reference look up including news, among other things. Wireless network and Internet access through PDAs is the most recently added feature, one that is expected to ensure the long-term popularity of PDAs. Although use of PDAs seemed to be exploding in the past 2-3 years, a recent study from Research Group International Data Corp. indicates that global shipments of handheld devices fell 10 percent from last year, down to 2.6 million in the second quarter of 2002. This is 17% off the result of the first quarter of 2002.[1] In the US, which is the biggest market for handhelds, shipments were off 19% from first quarter, but up 8% over the second quarter of 2001, to 1.3 million.[2] A similar trend can be expected in Canada. Thus the international decline in sales hasn't yet affected North America.

Wireless connectivity has been around since the beginning of the last century with the invention of the radio.[3] Although the technology has become more sophisticated the concept still remains the same: access to data at any time from anywhere. Cellular phones have highly popularized personal wireless connectivity over the past decade and now the distinction between cell phones and handheld devices is becoming blurred. Though the integration of these devices has not yet been perfected, the technology exists and is quite effective. Thus, it is the purpose of this project to review current devices and technologies in wireless portable devices and evaluate them for their effectiveness in the healthcare industry, and specifically at Cancer Care Ontario – Ontario's leader in cancer information, research, treatment and services.

With wireless networks becoming mainstays, mobile computing has gone far beyond just the PDA and cell phone (or SmartPhone). Other portable devices today include lap tops, tablets and even devices at the other end of the size spectrum that are considerably smaller than PDAs. In terms of types of devices there are essentially two major characteristics that must be considered:

1. The operating system (OS)
2. The form factor

In the context of this study, operating systems will be limited to Palm OS or Windows CE OS and form factors to SmartPhones, Handheld devices (i.e. PDAs), or Tablets.

The Palm operating system has a larger portion of the market, but Windows based devices have started to gain greater acceptance in the last couple of years. This greater acceptance has resulted in increased market share for these Windows CE devices.[4] The Windows operating system for portable devices, which is typically Windows CE, has a user interface based on the well known and very widespread Windows 9x operating system. Most windows-based PDA devices now use the Pocket PC 2002 version of this OS. This operating system has the added benefit over conventional Windows of "instant on" access since the portable devices do not have a hard drive. The Palm OS has been popularized because of its simplicity, reliability, and stability.

The second consideration, the form factor, varies considerably. In the list of form factors above, each is larger in size than the previous. This also means that it is heavier than the previous, but also has a larger screen with better resolution and typically also more features and greater functionality. There are numerous competing companies offering devices in each type category. The PDA is the most established type, followed by the SmartPhone and then the Tablet device. Tablets have been available for a few years, but their design and format have not been standardized. First generation Tablets have been extensively tested in a healthcare setting since they have been identified as useful devices in this vertical market. Standards for the SmartPhone have only recently begun to establish.

(b) The Canadian Healthcare Industry and Technology Use

The Healthcare industry in Canada is highly complex. It is predominantly a publicly financed, privately operated system with legislation at both the federal and provincial levels. Funding also comes from both levels of government. Therefore funding allocations are often politically driven and peak near election time. Technology funding has traditionally been poor in this industry (typically around 4% of revenues while in other industries the norm is upwards of 10%). As a result, the adoption of non-medical technology has lagged by about 5-10 years behind other industries. Hospitals in Canada must abide by the *Hospitals Act* as well as other applicable legislation. Physicians and

other clinicians often also have their own legislation as well as codes of ethics, which are enforced by their licensure college.

A unique feature of the healthcare industry is that physicians act as hospital consultants and thus are never (or at least rarely) considered employees of the hospital. Furthermore, their compensation comes directly from the provincial government OHIP reimbursement program. As a result healthcare is a physician driven industry. And physicians have traditionally been considered poor adopters of non-medical technology, even when it benefits patient care. Effectively, the reasons for this are cost (the physicians usually have to pay out of pocket) and a lack of time to learn how to use the new technology (they are already inundated with keeping up with new medical practices that prevent them from having time to learn or receive training on new computing technology).

Something promising though is that younger physicians are better adopters of new technology and are using it right from medical school.[5] Further, despite the dot com bust, healthcare institutions continue to slowly increase their investments in technology to try and reach the levels of other industries over time.[6] The requirements for good new technology in healthcare are as follows:

- Cost (i.e. low cost)
- Convenience (i.e. high levels of convenience)
- Complexity (i.e. low complexity)

The "3 C Factors" thus become very important.[7] These factors are common requirements to both administrators and clinicians (such as physicians). In terms of enabling wireless computing in healthcare there are more specific considerations cited by one author. Wireless connectivity, and thus physician mobility, must include the following common vision:[8]

- Provide strong integration into healthcare workflow with mobile devices
- Enable wireless networking (LAN, local area network) connectivity to critical information and services
- Extend data access to wireless access outside the hospital/institution (WWAN, wireless wide area network)

The full implications of this "wireless vision" will be considered in depth later.

(c) Portable Devices and the Wireless Web in Healthcare

"Every industry in [North] America uses wireless, Internet technologies and handheld computers—every industry except healthcare, the largest vertical market on the planet."[9] This is a highly blunt statement, but one that is mostly still true. ICTs (Internet and Communications Technologies) in general are under-utilized in health care. This is however slowly changing. Recent studies show that 84.5% of physicians would consider using a handheld computer.[10] In Canada today 28% of physicians use a PDA. This is up 47% over 2001.[11] It is therefore reasonable to estimate that by 2005 about half of physicians will be using a handheld device.[12]

Male physicians and medical and surgical specialists are more likely to use PDAs over females and GPs respectively.[13] Perhaps the biggest way in which PDAs are proliferating into the physician arena is through the MD University training programs. Many schools are now requiring their medical students to use PDAs (typically Palm based devices) as part of their training.[14]

Handheld and portable devices offer many benefits to physicians and indeed health care. Some of these include:[15,16]

- Handy access to patient data
- More accurate and timely entry of data
- Less costly to install than wired networks, especially in older buildings
- Saves time by eliminating frequent trips to fixed terminals
- Reduces medical errors

Conversely there are also some drawbacks that must be considered such as:[17]

- Occasionally slow network performance
- Poor battery life
- Work styles must change to accommodate technology

Some of the many overall challenges of using wireless devices have included supporting legacy applications, controlling rising costs and needing to comply to government regulations and legislation (such as the PIPEDA and equivalent Ontario legislation which is currently tabled as a Bill in cabinet).[18,19] All of these provide obstacles, but thankfully none of which cannot be overcome or controlled.

Currently there are hundreds of available medical and health related applications for PDAs and other portable devices. These include online reference tools, databases for patient tracking procedures, medical equations calculators, paging/messaging, note

generation, dictation, patient record access, drug prescribing, and billing (for the US).[20] The list is much longer than this in fact and there are indeed numerous options for each of these application types. Integrating these commercially available applications into your current PC based applications can be challenging if not impossible.

Interestingly enough, physicians have reasons to prefer PDAs over conventional or traditional alternatives. Some of these preferences include:[21]

- Easily accessible drug information
- Treatment recommendations
- Patient education materials
- Uniform user interface
- At least annual database updates
- Constant dynamic nature

Wireless infrastructure technologies have many uses in health care. A variety of health care institutions are using them today, mostly in a small scale. Some of the applications include bedside charting and access to patient records, nurse shift reports, admission assessment, emergency department use, supply inventory/materials management, monitoring of vital signs, pharmaceutical monitoring and ordering, compliance and decision support.[22,23] Most of these small scale applications result from inefficiencies caused by gaps in space or time between the point of care and the availability of relevant data. There are many factors that must be considered when evaluating wireless devices. Many of these are listed below in Figure 1.[24]

Figure 1 – Factors in Evaluating Wireless Devices

Affordability	Modality
Battery Cost and Availability	Operating System
Business Model	Portability
Developer Availability	Power Requirements
Ease of Use	Screen Size
Ergonomics	Security
Form Factor	Speed
Fragility	Theft Potential
Function	Tool Availability
Insurance	Total Cost of Operation
Mean Time Between Replacement	Unique Features
Media	

Energy consumption and therefore short battery life have always been a problem with personal computing devices.[25] This is no different when considering wireless portable devices. Devices lacking a bootable hard disk (i.e. those running on the Palm OS and Windows CE) have much better power management and battery life is acceptable. Devices such as Tablet PCs however currently have poor battery life. This is especially important in the healthcare industry where battery life is expected to be at least as long as a typical clinician work shift, which can be from about seven to twelve hours in length. Using external lithium polymer batteries can help circumvent this problem. Some lap tops and tablets now have optional or integrated lithium polymer batteries.[26] Another option is to have frequently placed docking stations and charging units throughout the clinic and patient areas.[27]

A final note is required in relation to potential electromagnetic interference in health care institutions. Many studies have been conducted investigating this phenomenon.[28,29] The only verifiable conclusion thus far is that WLAN (i.e. 802.11b) technology does not affect the operation of electronic medical devices and machinery as it operates on the 2.4GHz band. The results for cellular technology are much less conclusive however. Most studies site problems and errors resulting from cellular phone use near and around electronic medical devices and machinery.[30] This is why most hospitals these days forbid the use of cellular phones inside the building walls. Some studies still claim that there is no conclusive evidence[31] that interference indeed does cause problems in the use of these devices which makes it difficult to ascertain a true answer to this question.

(d) The Context of Cancer Care Ontario

Cancer Care Ontario (CCO) is the Ontario cancer agency, and the principle advisor to the Ontario government on all issues related to cancer. CCO manages ten regional cancer centres (RCCs) in Ontario. Four more are scheduled to open over the next five years. CCO is recently underwent an extensive province-wide information management strategic planning process that encompassed all providers of cancer services and treatment. One component of this strategic planning process is technology infrastructure. This pilot investigation is thus very timely.

It was noted earlier that the healthcare industry is a physician driven industry. Indeed in the case of this pilot investigation the request to pursue the feasibility of portable and wireless access to information was initiated by physicians. This

immediately gives the potentially eventual rollout of portable wireless connectivity at CCO a high probability of success, assuming the ensuing proposal is approved. The likely users of the portable wireless devices at CCO won't be limited to physicians however. Other clinicians will definitely require access, and more importantly so will senior administrators. Take note that in the organizational culture of CCO, senior administrators are often also physicians. This culture is slowly changing however.

Another enabler of success for this project is the probable near future funding allocations for information management and technology that will result from the information management strategic planning process. To compound this, a network infrastructure program for healthcare organizations in Ontario has been underway for about a year now and is continually expanding. It is known as the Smart Systems for Health (SSH) initiative, and it is connecting healthcare organizations across Ontario, currently only via hard wired lines. Other projects underway at CCO that will also facilitate this project are the existing Virtual Private Network connectivity and the new Content Management system which will rollout this fall.

Cancer Care Ontario currently is using a proprietary clinical information system that was designed in house. It is known as OPIS – Oncology Patient Information System. As part of an already approved information management project known as ICIS (Integrated Clinical Information System), OPIS is being replaced by a more sustainable, outsourced solution. This clinical information system is called Multi-ACCESS Oncology Information System, a product of the American company IMPAC Medical Systems, Inc., based in Mountain View, California. Multi-ACCESS will replace OPIS at two RCCs in early 2003 and then it will be implemented at the remaining RCCs over the next 3 years. Although Multi-ACCESS isn't currently wireless enabled, IMPAC is dedicating significant resources to creating a wireless access solution consisting of web-based software. Compatibility between a portable wireless device selected as a result of this study and the Multi-ACCESS wireless solution should be guaranteed.

(e) A Scan of Emerging Technologies

Beginning with the smallest form factor, the SmartPhone, an environmental scan gives us a few devices currently available that has an integrated organizer, cell phone, pager (SMS messaging), and wireless Internet/e-mail functionality all in one. The device chosen for investigation in this study is the Handspring Treo Communicator, which is a Palm OS based device. It comes in a few different models, but the one reviewed most

extensively is the Treo 180 which is a monochrome version of the GSM/GPRS device available with voice/data services from Rogers AT&T Wireless. The Treo does *not* have 802.11b wireless or Bluetooth functionality. Its wireless access is limited to WWAN (wireless wide area network).

In the traditional PDA form factor, the device that was reviewed is the Compaq iPAQ (3800 and 3900 series models), which is now under the Compaq-acquired HP line. The iPAQ runs on a Windows CE Pocket PC 2002 operating system and does *not* have integrated wireless capabilities. However, used in conjunction with a PCMCIA card expansion pack and appropriate PCMCIA card(s), the iPAQ can realize a wireless environment through a WWAN card and/or Wi-Fi (802.11b). The WWAN card tested with this device is the Sierra Wireless Aircard 555 used in conjunction with Bell Mobility's recently released CDMA2000 1xRTT advanced cellular network. The Aircard 555 also has voice functionality, but not through an intuitive phone-like form factor. A Standard PCMCIA WLAN card was also used.

One other much larger form factor, a Tablet PC, was also reviewed. Microsoft has focused a great amount of resources on developing its Windows XP Tablet PC edition, which is a superset of the Windows XP Professional edition. Officially released on November 7th, 2002, the Tablet PC edition of Windows XP has been available on Acer's Convertible Tablet/Notebook computer model TM C102Ti since about early October. Its "convertible" name implies it acts as both a Tablet and a Notebook computer. The Acer tablet has built in Wi-Fi capabilities, and can also accept the Sierra Wireless Aircard 555 through its one PCMCIA card slot for wireless data and voice functionality using the Bell 1x network, as with the iPAQ above. Although larger than the other two devices, the Tablet PC has the advantage of having the completely familiar Windows XP interface and "almost full" sized screen and keyboard, with the option of using a digitized pen for input (both as a mouse-type input and for hand writing).

Chapter 3: Objectives

(a) Problem Statement

As a result of the current context of wireless portable devices and the tremendous potential these devices can bring to the healthcare industry, CCO embarked on a pilot project at one of its regional cancer centres (RCCs), the Hamilton RCC. This project acted as a proof of concept; if successful other RCCs could follow suit and begin to deploy wireless portable devices as well. Specifically, the context is that wireless technologies have begun to stabilize and thus their performance is predictable. Furthermore, numerous cases of the use of wireless technologies in health care are now available from which to learn. Ultimately the need for wireless technologies at CCO must be driven by better patient outcomes as well true cost-benefit over the status quo.

(b) Research Questions

This study sought to answer a variety of research questions. These range from the technical, to the benefits for the clinicians, to the benefits for the patient. Specifically the questions include:

1. What is the current state of wireless technologies and how are they being used in health care in North America?
2. Can wireless technologies be sufficiently secured for a health care environment, especially keeping patient confidentiality in mind?
3. Will wireless networks affect the operation of other electronic devices in cancer centres such as chemotherapy pumps and/or radiation therapy machinery?
4. What types of portable and handheld devices are available today and which ones are most appropriate for the CCO environment?
5. What should be the operating system of choice for these devices, i.e. Windows (CE or NT based) or Palm?
6. Is wireless access required inside and/or outside of the cancer centres?
7. Do clinicians, and especially physicians, desire wireless access to applications through portable and handheld devices? Will their practice benefit as a result of wireless access?
8. What benefits will the patient gain as a result of wireless technologies?
9. What is the cost-benefit of wireless technologies over the current situation?

(c) Goals and Outcomes

The desired goals of this study are simple. The first goal is to produce a proof of concept that CCO users can connect wirelessly, in a secure fashion, to the CCO network and applications both inside the RCC (i.e. via WLAN, or 802.11b technology) and outside (i.e. via WWAN, or GSM/GPRS and CDMA2000 technology). The second goal is to establish how wireless access using portable and handheld devices can integrate with current processes at the regional cancer centres.

The target outcomes include better patient care, improved clinician effectiveness, and proven cost-benefit.

(d) Paradigm, Assumptions and Limitations

Although this study began using a "positivist" paradigm, over time it evolved somewhat towards an "interpretive" paradigm. Therefore, some of the research questions noted above were not known before the study began. This wasn't the intended approach, but as secondary research was conducted and as the wireless technologies were explored and tested it soon became clear that not all of the research questions were correct and not all that should have been asked had been asked.

There is one important assumption in this study that is noteworthy: that the results of this study at the Hamilton RCC are also applicable to all other RCCs in Ontario. For the most part this is a valid assumption. However, there are situations where this assumption was deemed invalid. These are noted in the results and discussion chapters.

One of the limitations is directly related to the assumption noted above; that the results may or may not be applicable to the other cancer centres in Ontario. Another limitation is the sample size of the primary research. This is especially true with the pilot program, since only two users tested the devices in a clinical setting. A final limitation was the availability of devices and technology to test. Much of the availability was a result of limited funding, but another important contributor is simply that new wireless technologies and wireless enabled devices are being announced monthly, if not weekly. There was thus an imposed limit on what was reasonable to test given the timelines and scope of this study.

Chapter 4: Methodology

(a) Design

Beyond the literature review, two types of research were conducted for this study. The first was a survey questionnaire of CCO staff and the second was a small pilot program consisting of users testing the devices in a work and/or clinical setting. In addition to these research methods, a high level cost-benefit analysis was conducted in order to fulfill that component of the research questions. Any remaining research questions not answered by the above were considered during the literature review.

(b) Sample Description

The sample for the survey questionnaire consisted of all HRCC staff (approximately 500 individuals) and a sub-set of staff at all other Cancer Care Ontario locations, including the eight other cancer centres and the provincial office in Toronto, Ontario. The sub-set typically consisted of physicians and members of the senior executive at the non-HRCC locations, but sometimes also included others such as researchers, nurses, information technology staff and other clinicians. It is therefore estimated that the potential total size of the survey questionnaire sample was 650. Demographic details of the respondents are included in the next chapter.

The group of users who made up the pilot program were all from the Hamilton RCC. They consisted mostly of physician clinicians, but also administrators and information technology staff. These individuals were approached to participate in the pilot program. Everyone who was approached agreed to be involved. Again, more details follow in the next chapter.

(c) Data Collection and Analysis Procedures

For the survey questionnaire all results were collected electronically through the CCO intranet and a web-based survey submission tool that was developed in-house. Before completing the survey, all participants were asked to read the instructions and submit the consent form (see Appendix A). Raw data from the survey questions were stored in a database and then analyzed using Excel after the close date of the survey. Prior to the release of the survey a number of individuals were asked to review the

questions for clarity, correctness and readability. Analysis was performed using standard statistical techniques. An overall analysis was conducted as well as sub-analyses that were based on specific demographic factors that were of interest. A copy of the survey questions can be found in Appendix B.

Since the pilot program was qualitative research the methodology used was less precise. Typically it consisted of:

- Users being trained on how to use the device for about an hour;
- Spending a few days familiarizing themselves with the features and technology;
- Using the device for one to two weeks in a work and/or clinical setting, while receiving ongoing technical support throughout this time if needed; and
- Feedback in an informal, conversational environment after the pilot testing was completed.

In some cases further pilot testing continued beyond the last component. Results of the feedback were documented and summaries are included herein.

Chapter 5: Results & Analysis

(a) Survey Questionnaire

The Wireless Portable Device Access survey questionnaire was administered between November 5, 2002 and November 14, 2002. It was accessible electronically through the Cancer Care Ontario intranet site and therefore only employees who have access to the intranet could complete the survey. An invitation to complete the survey was sent to:

- All HRCC staff since that is where the pilot program is occurring
- Senior executives and administration, physicians, other clinicians, and other select staff at the other CCO locations (the other regional cancer centres and the provincial office in Toronto)

In the ten day period a total of 129 responses were received though, as expected, 87 of them were from the HRCC. This response rate was higher than was expected. Prior to starting the survey it was expected that approximately 80-100 staff members would participate.

Nine participants experienced difficulties accessing the survey. There were two reasons for this:

1. Incorrect proxy server settings on the user's computer
2. Attempting to access the web page without a connection to the CCO VPN

It is not known how many of these users who initially experienced problems were able to eventually complete the survey since the submission process was anonymous. One participant also had a problem because the server was temporary down when he tried to access the survey. A further two users reported experiencing difficulties completing question 8 (described further below). No other users reported this problem and indeed answers from others refute the problem that the two mentioned users described.

Table I shows the breakdown of respondents in terms of location. This was asked in question 2.

Table I – Respondents by Location

Location	Number of Respondents
HRCC	87
KRCC	5
LRCC	1
NEORCC	7
NWORCC	4
ORCC	5
TSRCC	13
WRCC	2
Provincial Office	5
TOTALS	129

Table II shows the distribution of respondents based on age and gender. These were asked in questions 4 and 5 respectively.

Table II – Respondents by Gender and Age

Gender	Number of Respondents
Females	73
Males	56
TOTALS	129
Age Group	**Number of Respondents**
20-29	7
30-39	53
40-49	50
50-59	16
60+	3
TOTALS	129

Table III shows the breakdown by job role. These results were taken from the answers to question 1.

Table III – Respondents by Job Role

Job Role	Number of Respondents
General Administration	9
Health Information Systems/Transcription	3
IS/IT or Decision Support	2
Medical Oncologists or Haematologists	13
Nurses	13
Other Physician	5
Pharmacists	1
Physics	13
Radiation Oncologists	22
Radiation Therapists and Dosimetrists	7
Research and Clinical Trials	10
Senior Executive	5
Surgical Oncologists	3
Other	23
TOTALS	129

Table IV shows the responses to question 3 – How do you rate yourself in terms of computer technology competence?

Table IV – Respondents by Computer Competence Level

Competence Level	Number of Respondents
Power User	8
Advanced User	36
Average User	77
Novice User	8
TOTALS	129

The results to the above now set the stage for the answers to the questions which deal directly with wireless devices and access. The first of these was to ask the participants what devices they are currently using. Participants were asked to check off all that applied (from the list of Cell Phone, PDA, Pager, Lap Top or None). Consequently, the totals do not add up to the sample size of 129. The results are shown below in Table V.

Table V – Respondents by Current Device Use

Device(s)	Number of Respondents
Cell Phone	95
PDA	48
Pager	96
Lap Top	72
None	8
2 devices checked	45
3 devices checked	26
All 4 devices checked	31

Question 7 asked the participants if they used the above devices predominantly for Clinical/Business Use, Personal Use or Both. In the answers below (Table VI) the eight participants who answered "None" above are omitted since they don't use the devices at all.

Table VI – Respondents by Type of Use

Type of Use	Number of Respondents
Clinical/Business Use	26
Personal Use	11
Both Clinical/Business and Personal Use	84

The eighth question in the survey asked participants to rank a list of computer applications in terms of current use (i.e. on their desktop computer). Each number one ranking received a "score" of 10, number two rankings received a "score" of 9, etc. As a result, the following ranking of the applications resulted as shown in Table VII.

Table VII – Respondents Ranking of Applications Used on Desktop PCs

Application	Score	Rank
Exchange (e-mail, calendar, contacts, tasks)	1147	1
Web Browser	912	2
Word	907	3
OPIS	757	4
PowerPoint	606	5
Excel	575	6
Workstation Documents (My Documents)	496	7
Access	321	8
OPIS 2000	309	9
Web OPIS	208	10

Questions 9 and 10 asked users if secure wireless access of the above applications within and outside of their work location's building would be useful. The results are shown in Table VIII.

Table VIII – Respondents for Wireless Access Within and Outside the RCC

Access Within	Number Answered	Access Outside	Number Answered
Yes	60	Yes	70
Somewhat	48	Somewhat	34
No	21	No	25

The final question, question 11, was analogous to question 8, but asked the participants to rank the same list of computer applications, this time for wireless access. Also the participants were asked to rank only the top 3 applications of their choice. The results in Table IX summarize question 11; the same "scoring" system was used to analyze question 11 as was used for question 8.

Table IX – Respondents Ranking of Most Wanted Wireless Applications

Application	Score	Rank
Exchange (e-mail, calendar, contacts, tasks)	1146	1
OPIS	591	2
Web Browser	506	3
Word	384	
Workstation Documents (My Documents)	320	
OPIS 2000	112	
Web OPIS	82	
Excel	77	
PowerPoint	67	
Access	55	

Some further sub-analysis was conducted on some of the questions based on certain demographic factors. They included:

- The targeted job roles (i.e. physicians and senior executive)
- Location specific analysis
- Age specific analysis

The results of these are shown below.

All of the 10 respondents who indicated their job type as Research/Clinical Trials were from HRCC. They consisted of all levels of users (i.e. Power, Advanced, Average and Novice) and were in the age groups 20-29, 30-39, and 40-49. There was no significant variation by gender. These 10 participants use a variety of devices currently. Table X shows how they responded to questions 9 and 10.

Table X – Respondents for Wireless Access Within and Outside the RCC (Research/Clinical Trials Users Only)

Access Within	Number Answered	Access Outside	Number Answered
Yes	2	Yes	6
Somewhat	7	Somewhat	2
No	1	No	2

For question 11, the rankings were as follows:

1. Exchange
2. OPIS
3. Word

Of the 13 respondents who were Medical Oncologists or Haematologists, 6 were from HRCC, 1 from KRCC, 1 from ORCC, 3 from TSRCC and 2 from WRCC. Nine of the users considered themselves Average, while the other four considered themselves Advanced. None of the respondents were in the 20-29 age group, but more than half were in the 30-39 age group. The remaining respondents were in the 40-49, 50-59 and 60+ groups. Seven of the respondents used all four devices currently (PDA, Cell Phone, Pager and Lap Top) and all of the respondents use at least one of the devices currently.

Medical Oncologists and Haematologists were likely to want wireless access both inside and outside of their location's building, as is indicated below in Table XI.

Table XI – Respondents for Wireless Access Within and Outside the RCC (Medical Oncologist Users Only)

Access Within	Number Answered	Access Outside	Number Answered
Yes	6	Yes	9
Somewhat	6	Somewhat	2
No	1	No	2

For question 11, the rankings were as follows:

1. Exchange
2. OPIS
3. Browser

Twenty-two Radiation Oncologists completed the survey, 10 from HRCC, 1 from LRCC, 1 from NEORCC, 2 from NWORCC, 2 from ORCC and 6 from TSRCC. Almost all of the users considered themselves either Average or Advanced, with only one Novice user. This group was somewhat dominated by males at 16, versus 6 females. Once again, there were no respondents in the 20-29 age group, but almost half were in the 30-39 age group. The rest were in the 40-49, 50-59 and 60+ groups. Half of these participants currently use all four devices and all use at least one.

Table XII shows the results of questions 9 and 10 for this group. They too show promise for the desire of wireless access.

Table XII – Respondents for Wireless Access Within and Outside the RCC (Radiation Oncologist Users Only)

Access Within	Number Answered	Access Outside	Number Answered
Yes	15	Yes	15
Somewhat	5	Somewhat	6
No	2	No	1

For question 11, the rankings were as follows:

1. Exchange
2. OPIS
3. Browser/Word

Although the number 3 ranking wasn't actually a tie, the results were close enough to deem both answers as important.

The Surgical Oncologist and Other Physician categories were considered together since the total number of respondents in these two groups together was 8. Four of these respondents were from HRCC and the other four were from KRCC; six of them considered themselves Average computer users while the other two considered themselves Novice. All of them were under 50 years of age. Three of the respondents currently use all four devices and the rest all use at least one.

Despite the lower mastery of computer use in this group of individuals, the desire for wireless access was no less. This is shown in Table XIII.

Table XIII – Respondents for Wireless Access Within and Outside the RCC (Surgical Oncologist and Other Physician Users Only)

Access Within	Number Answered	Access Outside	Number Answered
Yes	6	Yes	5
Somewhat	2	Somewhat	1
No	0	No	2

For question 11, the rankings were as follows:

1. Exchange
2. OPIS/OPIS 2000
3. Browser

The final target group, the senior executive group, consisted of 5 respondents, 3 from the Provincial Office, 1 from NWORCC and 1 from TSRCC. Two of these respondents considered themselves Average computer users and the remaining three considered themselves Advanced. This group was dominated by males – only one of the respondents was a female. One respondent was in the 30-39 age group and the remaining four were either in the 40-49 or 50-59. Two of the five respondents currently use all four of the devices while the remaining all use at least one.

This group seemed especially keen on having wireless access to applications, as is noticed below in Table XIV.

Table XIV – Respondents for Wireless Access Within and Outside the RCC (Senior Executive Users Only)

Access Within	Number Answered	Access Outside	Number Answered
Yes	4	Yes	4
Somewhat	1	Somewhat	1
No	0	No	0

Not surprisingly, since their primary role is not clinical (though some of these individuals likely come from a clinical background), OPIS was not listed as one of the top three priorities for wireless access. Thus the rankings for question 11were as follows:

1. Exchange
2. Word
3. Browser

The analysis by Location was mostly limited to the results of questions 9 and 10. In general though the following trends by Location were also noted:

- All the individuals that considered themselves Power users were from HRCC.
- Most of the Novice users were also from HRCC; only two individuals NOT from HRCC listed themselves as Novice users.
- Of the 42 respondents not from HRCC 28 (or 67%) were physicians or senior executives.

The results to questions 9 and 10 are tabulated in Table XV on the following page.

Table XV – Respondents for Wireless Access Within and Outside the RCC by RCC Location

HRCC			
Access Within	**Number Answered**	**Access Outside**	**Number Answered**
Yes	31	Yes	42
Somewhat	37	Somewhat	26
No	19	No	19
KRCC			
Access Within	**Number Answered**	**Access Outside**	**Number Answered**
Yes	3	Yes	2
Somewhat	2	Somewhat	1
No	0	No	2
LRCC			
Access Within	**Number Answered**	**Access Outside**	**Number Answered**
Yes	1	Yes	1
Somewhat	0	Somewhat	0
No	0	No	0
NEORCC			
Access Within	**Number Answered**	**Access Outside**	**Number Answered**
Yes	3	Yes	5
Somewhat	3	Somewhat	1
No	1	No	1
NWORCC			
Access Within	**Number Answered**	**Access Outside**	**Number Answered**
Yes	4	Yes	4
Somewhat	0	Somewhat	0
No	0	No	0
ORCC			
Access Within	**Number Answered**	**Access Outside**	**Number Answered**
Yes	5	Yes	4
Somewhat	0	Somewhat	1
No	0	No	0
TSRCC			
Access Within	**Number Answered**	**Access Outside**	**Number Answered**
Yes	9	Yes	7
Somewhat	4	Somewhat	4
No	0	No	2
WRCC			
Access Within	**Number Answered**	**Access Outside**	**Number Answered**
Yes	1	Yes	1
Somewhat	1	Somewhat	0
No	0	No	1
Provincial Office			
Access Within	**Number Answered**	**Access Outside**	**Number Answered**
Yes	3	Yes	4
Somewhat	1	Somewhat	1
No	1	No	0

The last group for sub-analysis was the Age group demographic. The following was noted for the various age groupings:

- The 20-29, 50-59 and 60+ groups consisted solely of Average and Advanced users.
- Therefore Novice and Power users were only found in the 30-39 and 40-49 age groups.

The answers to questions 9 and 10 are shown in Table XVI.

Table XVI – Respondents for Wireless Access Within and Outside the RCC by Age Group

20-29			
Access Within	**Number Answered**	**Access Outside**	**Number Answered**
Yes	2	Yes	2
Somewhat	5	Somewhat	3
No	0	No	2
30-39			
Access Within	**Number Answered**	**Access Outside**	**Number Answered**
Yes	27	Yes	32
Somewhat	20	Somewhat	14
No	6	No	7
40-49			
Access Within	**Number Answered**	**Access Outside**	**Number Answered**
Yes	20	Yes	26
Somewhat	19	Somewhat	11
No	11	No	13
50-59			
Access Within	**Number Answered**	**Access Outside**	**Number Answered**
Yes	9	Yes	9
Somewhat	3	Somewhat	6
No	4	No	1
60+			
Access Within	**Number Answered**	**Access Outside**	**Number Answered**
Yes	2	Yes	1
Somewhat	1	Somewhat	0
No	0	No	2

(b) Pilot Program

A small pilot program was conducted at the Hamilton Regional Cancer Centre. This pilot included testing all devices in a work setting. The preferred setting was a clinical one, but a non-clinical setting was also used when a clinical user could not be established. The pilot for the iPAQ handheld device began in early October of 2002. For the Treo it began in mid-October, and for the Tablet PC it began on November 1st, 2002.

All of the pilot studies are still continuing and are expected to be completed before the end of the 2002 calendar year.

The pilot testing of the iPAQ was in a non-clinical setting by two separate users. The iPAQ was tested to ensure network connectivity via WLAN and WWAN. It was tested for VPN connectivity using both network types. Other security topologies were tested in addition to VPN including WEP encryption and MAC addressing. Access to certain applications was also tested. Some of the applications tested included e-mail and PIM programs, Pocket Word and Excel, terminal services client (to access the user's PC desktop) and the Pocket Explorer browser. The voice capabilities of the WWAN card were tested to a limited extent. Details about the Compaq iPAQ models used can be found in Appendix C.

The Handspring Treo was tested in a similar fashion to the iPAQ, i.e. in a non-clinical setting. Only one Treo was purchased for the pilot program so it was tested by one user and then another separately and subsequently. A variety of shareware and trial software was tested on the device to attempt to realize the full potential of this converged wireless handheld device. This device can only be used for WWAN access, but has the benefit of a more functional built in cellular telephone and Palm OS functionality. Applications such as wireless Internet and e-mail were extensively tested on the device in addition to Word, Excel and PowerPoint document reading and editing.

The Acer Tablet PC received the most extensive testing during the pilot. These devices were tested in a fully clinical environment by two physicians at the HRCC. Although they were tested for both WLAN and WWAN access prior to deploying them to the physicians, in the clinical setting only the WLAN was used.

Turning now to the results of the pilot, each of the three device types will again be considered in sequence. Establishing WLAN and WWAN connectivity on the iPAQ was quite simple. Adding WLAN and WWAN connectivity does require additional hardware and software for the device however. And it adds considerable weight and bulk to the device itself. WLAN connectivity integrated well with the device as the drivers for the WLAN PC card automatically search for an available network in the vicinity. The WWAN card worked effectively as well however a connection and disconnection requires user intervention. Connecting requires about 20 seconds while disconnecting requires about 5 seconds. VPN authentication on the iPAQ proved to be non-trivial. Although a variety of VPN packages are available for the Pocket PC platform MovianVPN was the one tested. It has a VPN client for both the Pocket PC and Palm

OS. Only after great effort was a VPN connection established. Furthermore in some instances three to four attempts were required before appropriate communications were established between the iPAQ and the VPN server in downtown Toronto.

As already noted, applications testing on the iPAQ was limited. No device specific medical applications were available to test and therefore testing was limited to e-mail and other PIM applicaitons, the Internet, Pocket Word and Pocket Excel. All of these applications work sufficiently well. There are a number of medical applications commercially available for the Pocket PC platform, but these were not tested because of time limitations. Some demonstrations of using medical software on Pocket PC devices were seen at medical trade shows and they appeared to work well.

As with the iPAQ, the Treo was used in a non-clinical setting during the pilot. The Treo was found to be an extremely portable and well integrated device. The Palm OS functionality was as good as any Palm based device. One small drawback however with using the functionality was the small screen size. The cellular telephone was integrated well with the existing PIM software, but the quality of the phone was found to be less than acceptable at times. Specifically, the person at the other end of the call often heard their own voice echoing when speaking to the Treo user. Furthermore, placement of the headset to the ear of the Treo user was sometimes less than intuitive.

On the other hand, the wireless functionality and software available for the Treo worked extremely well. Numerous wireless applications are already available and many of them were tested. In particular, wireless corporate e-mail applications were evaluated. Two such applications were tested extensively. These included Handspring's TreoMail, which was designed specifically for the Treo, and Data Viz's Inbox To Go, which is an extension to its other main Palm OS package, Documents To Go. TreoMail was especially well integrated with the Treo specific features. It has superb synchronization capabilities allowing users to send mail from their handheld device and have those same messages be automatically copied to the Sent Items folder within the desktop e-mail client. Inbox To Go, although not integrating quite as well as the TreoMail application, had the benefit of viewing, editing and creating attachments right on the Palm device. Word, Excel, PowerPoint, PDF and various image formats were all compatible.

VPN connectivity was not possible on the Treo. This was not a device specific limitation, but rather a network specific issue. It was determined that the inability to establish a VPN connection was due to the method in which Rogers AT&T creates the

Internet connection in the Network properties of the device. The US-based wireless providers that carry the Treo do not have this limitation.

Some third party medical applications were tested on the Treo. Although they were not tested extensively, like most Palm based software they appeared to work well and as described by the developers.

The Acer Tablet PCs were the only clinically tested devices in the pilot. Two Tablet PCs were given to physicians to use during the patient encounter in clinics. Wireless connectivity (both WLAN and WWAN) was easily established on the Tablet PCs. In the clinical setting only WLAN access was used. The overall experience and use of a wireless device at the point of care was seen as extremely useful. One of the users had the following to say when referring to wireless technologies in general in health care and specifically at the HRCC:

> *The furtherance of such technology is the wave of the future. Access to clinical information while in the patient examination room is important - having to go out into the clinic conference room to look up information can be sometimes disruptive. In addition, having a computer unfettered by wiring more than makes up for the lack of computers in the examination rooms.*

Some limitations of the device were also noted however. These included the short battery life of the device, the somewhat flimsy nature of the device itself (especially in terms of the rotating screen) and the unimpressive nature of the Windows XP Tablet PC edition when it comes to health care applicability. The word ‘gimmicky’ was specifically used when describing the operating system and the pen writing operations, including the Windows Journal application, were essentially not used at all by the clinicians. Full feedback from some of the pilot users can be found in Appendix D.

(c) Cost Benefit Analysis

This cost-benefit analysis considers each of the three tested devices separately, focusing on the recommended type of use for each. The analysis also focuses on the actual costs rather than opportunity costs since the latter are difficult to analyze and quantify in the CCO environment. Although these opportunity costs aren’t detailed in terms of actual value they are explicitly noted and discussed. Furthermore, support, training, and upgrade costs are not included in the calculations.

Handspring Treo

The Handspring Treo requires considerable initial investment as well as ongoing costs. However, when compared to costs of purchasing and maintaining a cellular telephone, a Palm OS PDA and a pager the costs become more manageable. Consider the time savings and other convenience benefits and the Handspring Treo becomes quite attractive.

Table XVII below shows the cost breakdown of the Handspring Treo and compares it to the current status quo for an individual who is using a cell phone, PDA and pager. Note as well that the Handspring Treo provides the additional functionality of wireless e-mail and Internet. The "total first year costs" noted include the one time hardware/software purchases as well as the monthly and/or annual service fees, while the "cost per year thereafter" considers only the monthly and/or annual service fees.

Table XVII – Cost Breakdown for Handspring Treo 180

With Handspring Treo				**Status Quo**		
Treo (B&W model)	$800	(one time)		cell phone	$60	(one time)
				PDA	$400	(one time)
Voice Airtime	$50	per month		pager rental	$30	per month
Data Transfer	$50	per month		Voice Airtime	$50	per month
Wireless e-mail	$100	per year		Other software	$200	(one time)
Other software	$300	(one time)				
Total First Year Costs	$2,400			*Total First Year Costs*	$1,620	
Cost per year thereafter	$1,300			*Cost per year thereafter*	$960	

Some of the noted benefits of the Handspring Treo include the following:

- "Always" connected (and therefore savings of time)
- Wireless e-mail (and Internet)
- Integrated device (convenience of one device)
- Palm OS expandability
- Potential use for clinical reference (if needed)
- Works both in buildings (poor signal sometimes though) and outside (signal quality and strength is good outside)

HP/COMPAQ iPAQ

Two separate cost benefit analyses were conducted for the iPAQ. The first includes use of the Sierra Wireless Aircard 555, and therefore WWAN access in addition to WLAN access, while the second only considers WLAN access. Note that the cost estimates here do not include the infrastructure costs associated with wireless access points as they have further use beyond just the iPAQ's themselves. The reason the WWAN card costs are considered in a separate case is that the purpose of the iPAQ's must be decided before the costs can be determined. If the iPAQ's are to be used inside CCO buildings only then the WWAN card is not needed. If however the devices are to be used both inside and outside then both the WLAN as well as the WWAN cards would be needed. The major investment with the iPAQ and accessories is up front costs. However, the Bell 1x data network access can be costly (i.e. much more than the estimated $50 per month) if the amount of data transfer is not closely monitored.

Table XVIII below shows the costs for the iPAQ with the WWAN card and wireless access included.

Table XVIII – Cost Breakdown for iPAQ 3850

iPAQ with WWAN card		
iPAQ	$900	(one time)
Expansion pack	$200	(one time)
Sierra Wireless Aircard 555 (WWAN)	$600	(one time)
WLAN (802.11b) Card	$150	(one time)
1x Network Access	$50	per month
Total First Year Costs	$2,450	
Cost per year thereafter	$600	

Table XIX shows the iPAQ costs when only WLAN access is desired. Notice that for this scenario only up front costs are needed.

Table XIX – Cost Breakdown for iPAQ 3850 without WWAN Card

iPAQ without WWAN card		
iPAQ	$900	(one time)
Expansion pack	$200	(one time)
WLAN (802.11b) Card	$150	(one time)
Total First Year Costs	$1,250	
Cost per year thereafter	$0	

Some of the benefits of the iPAQ include:

- Portable, small device (but small screen as a result)
- Wireless connection (i.e. portability)
- Wireless works best in WLAN over WWAN
- Better ability to create custom medical/health software solutions for PocketPC 2002 OS (over Palm OS)
- Descent screen resolution gives flexibility of type of software
- Clinicians (nurses, pharmacists, physicians, RTs) can easily use device at point of care
- Form factor is intuitive and integrates well with current process

Acer Travelmate Tablet PC

Use of the Acer Tablet PC was a proof of concept exercise. The device is very portable and easy to use, but the Tablet PC features do not provide much enhanced functionality in terms of the CCO environment and applications. Furthermore, the device has not been designed with durability and ruggedness in mind. In short, the device is not extremely suitable for the healthcare environment. One other large limitation is the short battery life.

Nonetheless the following costing analysis has been performed. Again, the costs of the wireless access point infrastructure have not been included here. Table XX shows the results for use of the Acer with the WWAN card, and Table XXI shows the results for use of only the WLAN card.

Table XX – Cost Breakdown for Acer Tablet PC

Acer Travelmate Tablet PC with WWAN card		
Tablet PC (WLAN built in)	$3,800	(one time)
Sierra Wireless Aircard 555	$600	(one time)
1x Network Access	$50	per month
Total First Year Costs	$5,000	
Cost per year thereafter	$600	

Table XXI – Cost Breakdown for Acer Tablet PC Without WWAN Card

Acer Travelmate Tablet PC without WWAN card		
Tablet PC (WLAN built in)	$3,800	(one time)
Total First Year Costs	$3,800	
Cost per year thereafter	$0	

Some of the benefits of the Tablet PC include:

- Very familiar interface (i.e. Windows desktop)
- Full computer functionality in a portable device (but battery life short as a result)
- Wireless connection (i.e. portability)
- Wireless works best in WLAN over WWAN
- Great screen size and resolution (but size limits portability to some extent)
- Software compatibility issues are very limited (Windows XP, and pen use, only limitation)
- Clinicians (especially physicians) can use devices at point of care with patients

(d) Other Similar Studies in CCO

It wouldn't have been prudent to complete this study without canvassing the rest of the CCO network to get an understanding of what others have done in the areas of wireless and portable devices. In the investigation three RCCs were found to be using such a scheme. One RCC was using portable devices in a wireless environment while the other two were both using wireless infrastructure to connect a network of lap tops in the centre.

The first RCC, the Kingston Regional Cancer Centre (KRCC), was conducting a pilot program. This pilot program involved using Viewsonic Tablet PCs and Compaq iPAQs in a wireless environment at the point of care. Evaluation of their pilot program had not yet been performed.

The Grand River Regional Cancer Centre (GRRCC), in Kitchener, Ontario, was using a wireless network, in production, to allow physicians to connect to patient care information systems at the point of care during the patient encounter. In order to increase battery life in the lap tops the GRRCC replaces the CD-ROM with an optional secondary expansion battery which results in about 6 hours of battery life before necessitating a recharge.

Finally, the Windsor Regional Cancer Centre (WRCC) has the longest running wireless network in production. It has been using wireless for more than three years and, like GRRCC, is using lap tops only to allow physicians, and others, a wireless connection to the network backbone. The interesting thing about WRCC's thrust to introduce wireless is that it was implemented due to space constraints. More computers were required to meet the needs of the users, but there wasn't enough space to accommodate them. Therefore the best solution was to install wireless infrastructure and deploy lap tops with wireless capabilities to users. The resulting product has proven very successful to date.

Chapter 6: Discussion and Recommendations

(a) Recommended Action

The recommendations resulting from this study are listed below. Many of these have been discussed previously in this document but are summarized below for convenience. There are a total of eighteen recommendations, which are broken down into the following categories:

- General recommendations
- Wireless Technologies specific recommendations
- Portable Devices specific recommendations
- Operating System specific recommendations

It is important to realize that these recommendations were developed as an integrated set and shouldn't be considered piece-meal. Furthermore, the recommendations are not intended to be all encompassing since the research itself has not been all encompassing. Therefore, caution should be taken when applying the following recommendations to a context other than the one from which these results were derived, namely the Hamilton Regional Cancer Centre.

General recommendations:

1. Before proceeding with deploying wireless portable devices a local evaluation of the need should be conducted to include the type of access (i.e. internal or external) and the types of devices and applications.
2. Clinician/user buy-in must be achieved for success. Ensure that the users are involved in the process during the design phase.
3. Some in-house expertise is highly recommended for such an endeavour.
4. Applications such as Web OPIS need to be further developed to increase functionality and to be designed with the portable device form factor in mind. A slightly different version for each form factor used may be required.
5. Physical security of portable devices can be challenging. PDA sized devices can especially easily go missing or get stolen.
6. Short battery life of wireless portable devices can quite possibly lead to failure of a wireless initiative. All possible alternatives to extend battery life to 'full shift lengths of time' should be considered.

Wireless Technologies specific recommendations:

7. Wireless network security and user authentication must be at the heart of your technology model. Wireless access point hardware must be carefully selected and placed to meet strict wireless security standards.
8. The IEEE 802.11b WLAN wireless network standard is stable and proven. It does however have security vulnerabilities. For the time being it is the wireless standard of choice, but as the IEEE 802.11a protocol standardizes further it should be fully evaluated and tested as well.
9. Cellular WWAN 2.5 and 3 G (generation) technologies are now very prevalent. With CDMA2000 technology likely surpassing that of GSM/GPRS it is the more recommended technology at this time. However GSM will continue to have the benefit of being the more globally used standard.
10. Internal wireless access is appropriate for all RCCs. External wireless access is likely more appropriate for centres where physicians and senior management staff travel frequently and long distances. Prime examples of this would be the NWORCC and NEORCC (assuming availability of wireless network access in Northern Ontario).

Portable Devices specific recommendations:

11. It is not possible to recommend a specific device for all uses and applications in the Regional Cancer Centre environment. Rather, choosing a device should be based on specific needs and requirements.
12. The Handspring Treo, or a similar device, should be used by senior management type staff in order to integrate numerous devices that are currently used. Wireless Internet and e-mail is for those individuals who need to stay connected.
13. The Compaq iPAQ, or a similar device, should be used predominantly for internal wireless access for applications specifically designed for that form factor. It can also be used for PIM and e-mail access.
14. The Acer Travelmate should not be used in a production setting since the Windows XP operating system is not currently supported for numerous clinical applications. Tablet devices with internal wireless access using earlier versions of the Windows operating system are however very appropriate for use in clinics, the chemo suite, pharmacy, rads review, etc. Lap tops may be more appropriate

for certain situations. Tablets and/or lap tops with external wireless access (i.e. WWAN) are recommended for physicians who require access on the road, for instance when traveling to outreach clinics at far distances.

Operating Systems specific recommendations:

15. As with recommending devices, one single operating system cannot be recommended to meet the needs of all users, uses and applications.
16. The Palm operating system is the 'gold standard' when it comes to PDAs. The ease of use, minimum resource requirements, low cost and extensive availability of software make it the PDA operating system of choice for individual or personal use of devices as well as for personal information management (PIM).
17. Windows CE based operating systems (including the Pocket PC 2002 edition on the Compaq iPAQ) have specific benefits. They have the look and feel of Windows with considerably lower resource requirements. Furthermore, Windows CE can be used in PDA type devices as well as Tablets. Software development is more straightforward for the Windows CE platform as compared to the Palm platform and therefore is the recommended platform when application development is required. Windows CE based devices should be used when they are for 'group' use as opposed to 'individual' use.
18. Traditional PC based Windows operating systems are most familiar for end users. They are effectively required for full-fledged portable computers including lap tops and tablet PCs.

(b) Knowledge Transfer

One of the most important aspects of applied research today is knowledge transfer. This has also been noted specifically for health care research since knowledge transfer has been especially poor in this industry traditionally. The main step for knowledge transfer in the context of Cancer Care Ontario is to ensure that the IS/IT department managers and other key management staff are aware of the results, and more importantly aware of what has been done and where in terms of wireless networking and portable devices. Some of this knowledge transfer is already being facilitated through the CCO provincial IT Advisory Committee (ITAC). A presentation has already been conducted and a briefing document was distributed at that time as well.

Further knowledge transfer to the rest of the health care industry in Canada and elsewhere would also be desirable, though not required.

(c) Future Considerations and Research

There are three specific areas which deserve further investigation in this area. Firstly a formative evaluation of all the programs currently underway at regional cancer centres across Ontario is a necessary step before further financial and human resources are dedicated to the costly infrastructure required. There are already sufficient data and anecdotal evidence available to be able to conduct a sufficient evaluation of the programs at the four different cancer centres. Such evaluations must focus on the impact of these technologies on patient care.

The second desirable action is to develop device specific (or better yet, device agnostic, i.e. web based) applications for the CCO context. These could include modified versions of already existing applications such as OPIS and OPIS 2000. Testing of these applications will also be required on a variety of devices including Tablets, PDAs and SmartPhone form factors.

The final area is related to wireless network security, the area that carries the most risk with wireless device access. Investigating wireless security, and eventually developing standards, not only involves the network infrastructure itself, but also device specific security using smartcards, biometric security, etc. As noted in recommendation 26, carefully following the future direction of IEEE wireless standards, and specifically the 802.11a standard, is key.

Chapter 7: Conclusions

Wireless technologies are impacting a number of people and industries world-wide. For a variety of reasons, these technologies have the ability to change the way business is conducted, but best practices have not yet been established since wireless technologies are still evolving and indeed changing on a frequent basis. This is especially true in the health care industry that typically realizes high barriers to the introduction of new technologies.

Wireless portable device use in Cancer Care Ontario has been shown to have great impact for end user clinicians and managers. The impact on patient care however must still be determined. It is clear that user buy-in in the CCO context will not be difficult to achieve. The obstacles will no doubt be financial resources to purchase and maintain the devices, acquiring or developing in-house expertise of wireless technologies and creating and finding the best applications of wireless technologies and devices in the outpatient oncology environment. All of the regional cancer centres that have or are using wireless networks and devices must collaborate to collectively address best practices in wireless technologies. This will produce the best result for the entire network of cancer centres and indeed for cancer patients themselves.

Glossary of Terms

1x, 1xRTT – Bell Mobility's "next generation" wireless network built on CDMA2000 technology.

802.11a – An IEEE Standard for wireless networking. This standard is not well established yet but shows promise and better security over its predecessor the 802.11b standard.

802.11b - An IEEE Standard for wireless networking, the most common standard in use today.

803.15 (Bluetooth) – An IEEE Standard for short-range wireless networking (PAN, or Personal Area Network) that is based on the Bluetooth standard with a few enhancements.

CDMA – Code Division Multiple Access. A wireless protocol based on digital spread-spectrum technology. Each transmission is identified by a unique code, allowing multiple calls to use the same frequency spread at speeds of about 14.4 Kbps.

CDMA2000 – Code Division Multiple Access 2000. A third-generation wireless technology derived from the second-generation CDMA, developed by Qualcomm. CDMA2000 can be laid on top of an existing CDMA network. CDMA2000 is designed to provide a bandwidth of between 100 and 300 Kbps.

GPRS – General Packet Radio Service. A method of sending web information to mobile telephones at up to 100 Kbps. GPRS is viewed as one means of upgrading existing GSM networks with faster, 'always-on' wireless connectivity.

GSM – Global System for Mobile communications. A digital-cellular standard that uses time-division (TDMA) to carry multiple, simultaneous calls on the same frequency at 9.6 Kbps. The vast majority of European mobile phone networks are built in accordance with the GSM standard.

ICIS – Integrated Clinical Information System. The current EPR (Electronic Patient Record) pilot project at the CCO Regional Cancer Centres NWORCC (in Thunder Bay, Ontario) and NEORCC (in Sudbury, Ontario).

LAN – Local Area Network. A group of interconnected computers that share data, software, and storage devives. Wireless LANs are generally thought of as extending to a range of several hundred metres, such as that which Wi-Fi provides.

Multi-ACCESS – The name of the EPR software that is being used in part for the CCO ICIS project. This product is made by IMPAC Medical Systems, Inc.

OPIS – Oncology Patient Information System. The current, legacy EPR used and developed by Cancer Care Ontario.

Palm OS – The very common PDA operating system made by PalmSource Inc.

PCMCIA – Personal Computer Memory Card International Association. A standards organization that defined the PCMCIA bus, a credit-card-sized slot normally found on lap top computers that is used for RAM, wireless modems, and other add-ons. Also known as the PC card and card bus.

PDA – Personal Digital Assistant. A handheld electronic organizer that may provide Internet access and e-mail functions.

PIM – Personal Information Management. PDA applications that consist of an address book, calendar, notes and task items.

Pocket PC – A Windows CE operating system version used for Windows-based PDA devices.

SmartPhone – A cell phone with Internet access as well as on-board PDA capabilities; that is, an Internet phone with PDA capabilities. Every SmartPhone is an Internet phone, but not every Internet phone is a SmartPhone.

SMS Messaging – Short Message Service. A technology that is used to send limited text messages to mobile phones and is popular in Nordic countries and in Western Europe as an inexpensive alternative to wireless application protocol (WAP) enabled phones. Unlike WAP, SMS allows secure payment for mobile electronic commerce.

SSH – Smart Systems for Health. An agency of the Ontario government that is supplying infrastructure to connect all health care institutions in the provice.

Tablet PC – A PC that resembles a lap top but has mobility in mind. Tablet PCs are often in the 'slate' format that doesn't have a keyboard but rather uses a docking station or pen/touch input for entry.

WAN – Wide Area Network. Multiple local area networks tied together, typically using telephone company services. WANs may connect users in different buildings or different countries.

Wi-Fi – An increasingly popular wireless local area network standard for fixed and portable wireless devices. Also known as IEEE 802.11b.

Windows CE – A Windows-based operating system for portable and handheld devices that do not have a bootable hard drive.

WLAN – Wireless Local Area Network. A Wireless LAN that is typically based on the 802.11b standard.

WWAN – Wireless Wide Area Network. A Wireless WAN that is based on cellular technologies such as GPRS and CDMA2000.

Appendices

Appendix A – Survey Instructions and Consent Form

Pilot Investigation of Wireless Handheld Device Access to Cancer Care Ontario (in collaboration with McMaster University)

INSTRUCTIONS

Thank you for participating in our study. We are attempting to evaluate the impact of wireless handheld device access to CCO documents and applications. Wireless devices include Personal Digital Assistants (PDAs), smart phones and Tablet computers.
If you agree to take part in this survey, you will be asked to answer a short series of eleven questions related to your experiences with and desire for wireless access.
The information gathered in this survey is strictly confidential and anonymous to ensure your privacy.

If you have any questions regarding this survey, please feel free to contact Patrick Baldwin or Dr. Milena Head.

SUBJECT CONSENT FORM

Investigators: Patrick Baldwin (Hamilton Regional Cancer Centre), Dr. Milena Head (McMaster University), Alex Drossos (Cancer Care Ontario and McMaster University) & Gary Green (Hamilton Regional Cancer Centre)

Please click on the accept button below if you agree with the following statements:

- I have freely volunteered to participate in this study regarding wireless handheld device access to Cancer Care Ontario.
- I have been informed in advance about the nature of this study, what my tasks will be, and what procedures will be followed.
- I have been given the opportunity to ask questions and have had any questions answered to my satisfaction.
- I understand that the information gathered by the test group will be kept anonymous and thus will be held in strict confidence.
- I am aware that I have the right to withdraw consent and discontinue participation at any time.

Appendix B – Survey Questions

Pilot Investigation of Wireless Handheld Device Access to Cancer Care Ontario: A Questionnaire

Thank you for taking a couple of minutes of your time to complete this survey. The results of this survey will help us determine the need for wireless access to CCO applications from a variety of devices. This is a pilot project that is currently under review and your input is greatly appreciated.

Please answer the following questions using the instructions included for each.

1. What is your main job role at CCO (choose one only)?
   a) Medical Oncologist/Haematologist
   b) Radiation Oncologist
   c) Surgical Oncologist
   d) Other Physician
   e) Nurse
   f) Senior Executive
   g) Pharmacist
   h) Health Records or Transcription
   i) Radiation Therapist/Dosimetrist
   j) Physics
   k) Research/Clinical Trials
   l) IS/IT/Decision Support/ALR
   m) General Administration
   n) Other

2. At what CCO location do you work?
   a) GRRCC
   b) HRCC
   c) KRCC
   d) LRCC
   e) NEORCC
   f) NWORCC
   g) ORCC
   h) TSRCC
   i) WRCC
   j) Provincial Office

3. How do you rate yourself in terms of computer technology competence? (select one)

   a) Novice
   b) Average
   c) Advanced
   d) Power user

4. What is your gender?
   a) Female
   b) Male

5. What is your age group?
   b) 20-29
   c) 30-39
   d) 40-49
   e) 50-59
   f) 60+

6. Which of the following devices do you currently use? (check all that apply)

   - PDA
   - Cell Phone
   - Pager
   - Notebook/lap top computer
   - None of the above

7. Do you use the above device(s) mostly for: (select one)

   a) Clinical/Business use
   b) Personal Use
   c) Both Clinical/Business and Personal Use
   d) Don't use any

8. Rate the following CCO applications/files in order from most used (1) to least used (10), on any computer; rate only those that you use.
   - Microsoft Exchange (e-mail, tasks, calendar, contacts, notes, etc.)
   - Web browser (Internet Explorer or Netscape)
   - Microsoft Word
   - Microsoft Excel
   - Microsoft PowerPoint
   - Microsoft Access (i.e. database)
   - OPIS
   - OPIS 2000
   - Web-OPIS
   - Workstation Documents (i.e. "My Documents")

9. Would secure wireless access to applications from **within** your office/RCC (i.e. in the hallways/corridors, rooms other than your own office) be useful?
(select one)

   a) Yes
   b) Somewhat
   c) No

10. Would secure wireless access to applications from **outside** your office/RCC (i.e. while on the road, during travel) be useful?
(select one)

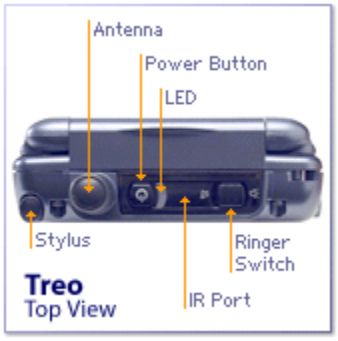
    a) Yes
    b) Somewhat
    c) No

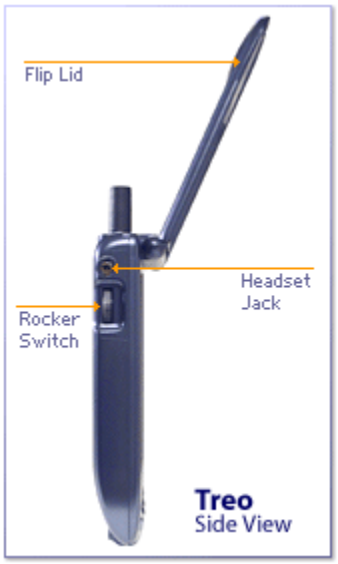
11. If you were able to access CCO applications/files wirelessly (remotely), what 3 from the following list would you most want to access?
(please rank them in order from 1 through 3, please rank the top 3 **only**)

    - Microsoft Exchange (e-mail, tasks, calendar, contacts, notes, etc.)
    - Web browser (Internet Explorer or Netscape)
    - Microsoft Word
    - Microsoft Excel
    - Microsoft PowerPoint
    - Microsoft Access (i.e. database)
    - OPIS
    - OPIS 2000
    - Web-OPIS
    - Workstation Documents (i.e. “My Documents”)

Appendix C – Pilot Program Device Details

Handspring Treo 180 SmartPhone





Item	Handspring Treo™ 180
Radio	GSM/GPRS 900/1900 MHz world phone
SRP	$249 with service activation $449 without service activation
Processor Technology	33 MHz Motorola Dragonball VZ
Memory	16 MB
Battery	Rechargeable Lithium Ion (internal) Up to 2.5 hours talk time Up to 100 hours standby time 3-4 weeks use with wireless mode off
Palm OS Version	Palm OS 3.5.2H
Built-in Software	PhoneBook Instant Lookup Date Book Plus SMS Messages Blazer web browser To Do List Memo Pad Advanced Calculator CityTime world clock Expense Wireless setup & desktop synchronization software (for both Windows & Macintosh): - Wireless setup/installer - One-Touch Mail™ (POP3) - Palm™ Desktop - HotSync® Manager - Link to Microsoft Outlook (Windows only)
Available Color	Steel Blue
Size	4.2" x 2.8" x 0.82" (10.8cm x 7.1cm x 2.1cm)
Weight	5.2 oz (147 g)
IR	Yes
Display	Monochrome (16 shades of gray)
Backlight	Yes
Built-in microphone	Yes
Additional Features	Rocker switch Ringer switch with vibrate option Headset jack Personal speakerphone Touch-screen with stylus Protective flip lid GPRS upgradeable upon availability
Available Services	Treo Mail email service (sold separately)

Compaq iPAQ 3800/3900 Series PDA

iPAQ 3950 pocket pc

specifications

Model	Compaq iPAQ™ Pocket PC 3950
Standard Features	• 400 MHz Intel® X-Scale Processor • 32 MB Flash ROM • 64 MB SDRAM • Docking Cradle - Universal USB or Serial with AC power and charging • 1400 mAh Lithium Polymer Rechargeable Battery
Display	• Color Transflective TFT LCD • 3.78" Low Power 16-bit color • Touch Screen • Resolution: 240 x 320 • Dot Pitch: .24mm • Color Depth: 64K Color
Input Method	• Touch-sensitive display • Soft keyboard • Character recognition • Handwriting recognition • Inking • Voice recorder
Easy Access Buttons	• 5-way joystick: up, down, left, right, push • Voice recorder • Backlight on/off
Input/Output Ports	• SD expansion slot • Infrared Ports: IrDA standard, 115 Kb per second • Speaker: Yes • Microphone: Yes • Audio In/Out Jack: 3.5 mm
Notification Systems	• Audible alarm • Solid yellow LED fully charged • Blinking yellow charging
Power Supply	• 1400 mAh Lithium Polymer rechargeable battery • Recharging supplied through docking cradle or AC adapter
Docking Cradle	• USB synchronization requires Microsoft® Windows® 98, 2000 or XP • Easily auto-synchronize data with your PC • Standard: Docking cradle with battery charger and Serial and USB port connection to PC
Software (preinstalled)	• Microsoft® Windows® CE • Calendar, Contacts, Tasks, Voice Recorder, Notes, Pocket Word,

	Pocket Excel, Pocket Internet Explorer, Windows Media™ Player (MP3), Calculator, Solitaire, Inbox (for e-mail), Microsoft® Reader (eBooks), File Explorer, MSN® Messenger, Terminal Services Client, VPN Client, Infrared Beaming, Clock, Align Screen, Memory, Volume Control • iPAQ Task Manager, iPAQ File Store, iPAQ Backup, iPAQ Image Viewer
Software on CD	• Microsoft® ActiveSync® 3.5 • Pocket Outlook® 2002 (e-mail, calendar, contacts and tasks) • Microsoft® Reader (eBooks) • Conduits Peacemaker Professional
Operating Temperature	32 to 104 degrees F (0-40 degrees C)
Operating Humidity	10% - 90%
System Requirements	• For ActiveSync® 3.5: Microsoft® Windows® 2000, 98, Windows NT® Workstation 4.0 or XP with a 486/33DX or higher processor (Pentium® 90 MHz recommended) • For USB Synchronization: Microsoft® Windows® 2000, 98 or XP • 12 MB of memory for Windows NT® or XP • Hard disk drive with 10 to 50 MB of available hard disk space (actual requirements will vary based on selection of features and user's system configuration) • Available 9 or 25 pin communications port (adapter required for 25 pin communication port) • CD-ROM drive • VGA or higher resolution graphics card • Mouse or compatible pointing device • USB port
Dimensions & Weight	• Unit: 5.3" x 3.3" x 0.6" (6.5 oz.) • Unit Package: 12.5" x 9.00" x 4.13" (3 lbs.)

Acer Travelmate TM C102Ti Tablet PC

TravelMate C100

Specifications

TravelMate C100	
Processor and core logic	800MHz ultra low voltage Mobile Intel® Pentium® III Processor - M[1]; 512K L2 cache; supporting Enhanced Intel® SpeedStep™ technology Intel® 440MX chipset
Memory	128MB/256MB of SDRAM
Display and graphics	10.4" TFT LCD supporting pen-based input, with 1024 x 768 pixels resolution,16 million colours SMI Lynx 3DM+ graphics chipset with 8MB of VRAM Simultaneous LCD and CRT display DualView™ support LCD rotates to convert from notebook to tablet mode
Storage subsystem	20/30GB or higher ATA/100 hard disc drive with Disc Anti-Shock Protection (DASP) External USB CD-ROM drive
Dimensions and weight	251 x 208 x 25.4/29.4mm (9.9" x 8.2" x 1-1.16") 1.4kg (3.2lbs) with 10.4" LCD
Power subsystem	ACPI compliant 26WHr Li-ion battery 3.5-hour battery life 1.5-hour rapid-charge, 2.5-hour charge-in-use time 50W miniature AC adaptor
Keyboard and input devices	Acer FineTouch keyboard : with a 5° curve, 84/85/88-key, inverted "T" cursor layout, 17.5mm spacing, 2.5mm (min.) key travel Five easy launch buttons Embedded numeric keypad Touchpad located in centre of palm rest 4-way Internet scroll key Electromagnetic Resonance (EMR) stylus Electromagnetic Resonance (EMR) pen
Audio	Audio system with two speakers; Built-in microphone SoundBlaster-Pro and MS-Sound compatible
Communications	Built-in 10/100Mbps Fast Ethernet, Wake-on-LAN ready Built-in V.90 56Kbps MDC modem with international PTT certification; Wake-on-Ring ready Optional 802.11b wireless LAN
I/O interface	USB ports (two) Ethernet (RJ-45) port

	Modem (RJ-11) port VGA/video portIEEE 1394 portInfrared (FIR) port Type II PCMCIA CardBus slot SmartCard interface slot DC-in jack for AC adaptor Line-in (external microphone) jack Line-out (headphones/external speakers) jack
Operating system	Microsoft® Windows® XP Tablet PC Edition
Other software	BIOS user and administrator passwords Acer Notebook Manager Acer Launch Manager Acer System Recovery CD Norton AntiVirus™ Adobe Acrobat® Reader™ Acer InviLink™ PlatinumSecret™ suite for SmartCard, including PlatinumPAS™ , PlatinumSecure™ and PlatinumKey™ ORiNOCO Client Manager Mircosoft® Reader[5]
Options and accessories	128MB memory upgrade module Higher-capacity hard disc drive InviLink™ access point Additional AC adapter Additional Li-ion battery pack USB floppy disc drive Infrared (IR) remote control External battery charger Additional EMR pen Additional EMR stylus Custom-designed leather case
System compliance	Microsoft® Windows® XP Tablet PC Edition ACPI 2.0 DMI 2.0 Intel® LANDesk® Client Manager 6.0
Warranty	One-year International Traveller's Warranty (ITW)
Quality and reliability tests	Temperature and Humidity test Acoustics test Electrostatic Discharge Immunity test Hinge Life Test Free Drop test Keyboard Switch Life test Weight and Pressure test Spill test Shock and Vibration test MTBF (Mean Time Between Failure) test
Special Tablet PC tests	Convertible Hinge Rotation test Screen Supports test LCD Scratch testLCD Ripple test Hook Durability test Two-way Latch Push and Slide test Stylus Holder test

Appendix D – Pilot Program Feedback

Tablet PC Pilot Program User Questionnaire
Answers from User #1

1. *How do you feel about the general usefulness of wireless networking?*

   It's very useful. The furtherance of such technology is the wave of the future. Access to clinical information while in the patient examination room is important - having to go out into the clinic conference room to look up information can be sometimes disruptive. In addition, having a computer unfettered by wiring more than makes up for the lack of computers in the examination rooms.

2. *How do you feel about the useful of wireless networking for specific applications?*

   OPIS – Very useful to be able to look up information while with patients.
   MEDITECH – Also very useful.
   WebOPIS – An excellent application in basic form but it needs work to be more useful. Specifically, 'back' buttons for Notes so that a user could cycle back and forth through different notes. In addition, having to click the 'search' button to is annoying – the normal Windows behaviour of using the enter key would be desirable. Moreover, the ability to add comments to notes (limited write functionality) would be nice.

3. *Are there any other applications you would like to see available?*

   Not particularly, but the availability of drug lists and other information would be very useful. This could be in IE favourites, websites that are saved locally, or even loaded programs (although this is more unlikely as they would need to be consistently updated).

4. *How useful did you find the Tablet PC in general (size, weight, portability – wireless range, logon / accessing network resource problems)*

   The size and weight of the unit makes it very handy to carry around. The screen is a little small and having the resolution set to the higher values can make things hard to read. There were problems with wireless access 'cutting out' sometimes, even when in close proximity to the WAP's. This may have had something to do with the machine going into sleep mode, although it sometimes appeared that the connection would cut out just switching between OPIS and Meditech. Also, knowing when the machine was in sleep mode or actually off was sometimes difficult. This user said that he took it back to his office more than once thinking that he had turned it off when it was in fact in standby mode.

5. *How often did you use the Tablet? Every day? Every Patient? Did you take it to clinic every day?*

   The unit was too fiddly to use on days when the clinic was very busy. On the clinically lighter days this user had more time to play with the machine and was able to use it successfully as a clinical tool.

6. *Did you use the tablet functionality, pen w/touch screen? Was tapping the onscreen keyboard or using the shortcut buttons useful?*

   This user didn't use the tablet functionality or the Windows Journal application and found the pen not as useful as using the keyboard in regular laptop mode.

7. *Did you experience any power problems with the Tablet (batteries, charging)?*

   The tradeoff between having the computer go to sleep and having the batteries run down is difficult to determine. This user found that the batteries appeared to run down quite quickly, but that the battery-saving standby mode could cause problems (see above). He sometimes kept the charging adapter in clinic with him so that he could connect the unit and keep it charged.

Tablet PC Pilot Program User Questionnaire
Answers from User #2

1. *How do you feel about the general usefulness of wireless networking?*

   Generally, it could be quite useful, but wireless would have to be transparent to the user for it to really work well.

2. *How do you feel about the useful of wireless networking for specific applications?*

   OPIS & MEDITECH – Limited usefulness. Clinical information needs as a Radiation Oncologist, are, he feels, not as dependent on OPIS and Meditech information as a Medical Oncologist's might be. All needed information is available in chart form. The ability to look at OPIS and Meditech while attending a patient in a clinical examination room is not as compelling as it might be for someone for whom that information is more vital.

   WebOPIS – Not used.

   PACS – Also limited usefulness, for quick reference only.

3. *Are there any other applications you would like to see available?*

   The ability to use email would possibly be useful, but a clinician might be tempted to spend a lot more time on their email in clinic.

4. *How useful did you find the Tablet PC in general (size, weight, portability – wireless range, logon / accessing network resource problems)*

   The size and weight of the unit makes it very handy to carry around. It might be very nice to have as a desktop replacement, if the user were able to quickly detach cords and take the unit with him or her, if need be.

5. *How often did you use the Tablet? Every day? Every Patient? Did you take it to clinic every day?*

   This user used the Tablet usually only on Wednesdays, in clinic. Most other days he either was in Simulator or Review, in the basement where the reception was low – to – non-existent, or he was in his office.

6. *Did you use the tablet functionality, pen w/touch screen? Was tapping the onscreen keyboard or using the shortcut buttons useful?*

   This user didn't use the tablet functionality or the Windows Journal application and found the pen functionality difficult to get used to. He did think however, that the Tablet functionality and Journal application would be very useful to someone who attended many meetings on a regular basis.

7. *Did you experience any power problems with the Tablet (batteries, charging)?*

   This user didn't use the unit enough to have any problems. He experienced a low power condition once or twice, the solution for which was simply switching the low battery for the charged replacement.

References

[1] Handheld Computer Shipments Dip, Palm's Grip Slips. New York (Reuters). July 25, 2002. E*TRADE Financial – Investing. Retrieved from the world wide web on August 1, 2002 https://us.etrade.com.

[2] Ibid

[3] Bergeron, Bryan. *The Wireless Web and Healthcare*. Chicago: HIMSS, 2002. p 12.

[4] Dehn, R. *Using Computers in Clinical Practice*. Physician Assistant, Volume 26(8). August 2002. pp 35-40.

[5] Noble, Suzanne. *PDAs and Hand-helds: World Without Wires*. Health Management Technology. Retrieved from the World Wide Web on July 5, 2002 http://www.healthmgttech.com.

[6] Zabrek, E. *A Physician's Odyssey: "eHealthcare" and Windows Powered Devices*. Pocket PC Magazine. Retrieved from the world wide web on July 5, 2002 http://www.pocketpcmag.com.

[7] Smithline, N. *HandHelds, The Holy Grail of Healthcare?* Proceedings of the 2002 Annual HIMSS Conference and Exhibition. Retrieved from the world wide web on July 5, 2002 http://www.himss.org.

[8] Jarvis, K. *Compaq in Healthcare…Bringing it All Together*. A Healthcare Solutions and Alliances Presentation. Retrieved from the world wide web on July 5, 2002 http://www.compaq.com.

[9] Rullo, D. *Why Work Wireless? How to reduce medical errors from the palm of your hand*. Health Management Technology. Retrieved from the World Wide Web on July 5, 2002 http://www.healthmgttech.com.

[10] Ebell, M. et al. *Family Physicians' Preferences for Computerized Decision-Support Hardware and Software*. J. Family Practice, Volume 45(2):137-41, 127-128, 1997.

[11] *Pulse: MDs' computer, PDA use on the upswing*. JAMC. October 1, 2002; 167(7), p 794.

[12] Today's News. *Physicians' Use of Handheld Personal Computing Devices Increases from 15% in 1999 to 26% in 2001*. Rochester, NY. August 15, 2002. The PR Newswire. Retrieved from the world wide web on July 5, 2002 http://www.prnewswire.com.

[13] Ibid 11

[14] Gaillour, F. *Mobile Computing in Healthcare*. Proceedings of the M-Commerce Summit, March 1, 2001. Retrieved from the world wide web on July 5, 2002 http://www.kihealth.com.

[15] Ibid 4

[16] Essex, D. *Wow! Wireless Works!* October 1999. Healthcare Informatics. Retrieved from the world wide web July 5, 2002 http://www.healthcare-informatics.com.

[17] Ibid

[18] Townsend, D. *Wireless in Healthcare: A Look at the Legal Risks*. Proceedings of Canada's First Annual Summit on Wireless Healthcare Technology, February 25-26, 2002.

[19] Martucci, J. et al. *The Future of Wireless Personal Digital Assistants (PDAs) in Healthcare*. Proceedings of the 2002 Annual HIMSS Conference and Exhibition. Retrieved from the world wide web on July 5, 2002 http://www.himss.org.

[20] Cordell, W and Peak, D. *The Palmtop Computer: Medicine's New "Peripheral Brain"*. MD Computing, Volume 9(4): 264-268, 1992.

[21] Ibid 19

[22] Ibid 16

[23] Ibid 5

[24] Bergeron, Bryan. *The Wireless Web and Healthcare*. Chicago: HIMSS, 2002. p 134.
[25] Bergeron, Bryan. *The Wireless Web and Healthcare*. Chicago: HIMSS, 2002. p 50.
[26] Electrovaya web site – The Scribbler Tablet PC. Retrieved from the world wide web on November 20, 2002 http://www.electrovaya.com.
[27] Bergeron, Bryan. *The Wireless Web and Healthcare*. Chicago: HIMSS, 2002. p 51.
[28] Segal, B. et al. *Risk of patient injury due to electromagnetic interference malfunctions: estimation and minimization*. 2001. Proceedings of the 2001 IEEE International Symposium on Electromagnetic Compatibility, Montreal, Canada. Pp 1308-1312.
[29] Gilfor, J. *Feature – Wireless Devices and Electromagnetic Interference in Hospitals, Urban Myth?* Retrieved from the world wide web on July 5, 2002 http://www.pdamd.com.
[30] Ibid 24
[31] Ibid 25