MeRC

McMaster eBusiness Research Centre

WIRELESS INNOVATIONS IN COMMUNITY HEALTHCARE

By

Norm Archer

archer@mcmaster.ca

McMaster eBusiness Research Centre (MeRC)
DeGroote School of Business

MeRC Working Paper No. 16

February 2006

McMaster University

WIRELESS INNOVATIONS IN COMMUNITY HEALTHCARE[1]

By

Norman Archer

MeRC Working Paper #16
February 2006

DeGroote School of Business
McMaster University
Hamilton, Ontario, L8S 4M4
Canada
archer@mcmaster.ca

[1] This research is supported by grants from the Ontario Research and Development Challenge Fund and the Natural Sciences and Engineering Research Council of Canada.

ABSTRACT

This paper describes a highly innovative project to improve the support of home healthcare in Simcoe County in Ontario, Canada, through a wireless system that provides online access for homecare nurses. In conjunction with the project, eight areas of research are being pursued in both administrative and clinical areas. Some initial results on business case analysis and development of the first modules are described.

KEYWORDS

Home healthcare, business case research, usability and technology acceptance, system interoperability, supply chain management, clinical and administrative decision support, self management of chronic disease

TABLE OF CONTENTS

1. INTRODUCTION

In developed countries there continues to be a substantial increase in emphasis on delivery of care on an ambulatory basis for chronically ill, aging, and recovering clients. This emphasis is driven largely by an aging population and increases in chronic illness and multiple co-morbidities. In addition, as technology and pharmaceutical advances occur, a greater proportion of acute (short term, serious illness or injury) patients are being released early from hospital and cared for at home to shorten expensive hospital recovery times and reduce costs. All of this has resulted in an increase in the demand for home healthcare services. The overall trend is driven by major health system restructuring initiatives, technological advances, and changing social values. The shift to homecare that is occurring is not just a shift in the site where healthcare is received, but it involves implications in funding, allocation, and delivery of home and community care services.

The Ontario system for homecare revolves around the Community Care Access Centre (CCAC) concept. There are 42 CCACs dispersed in various Ontario centres. They are not currently linked to hospitals in their geographic areas of responsibility, but the Ontario government has recently moved to regionalize healthcare by forming 14 Local Healthcare Integration Networks (LHINs) which will, in effect, regionalize the healthcare system by clustering related CCACs, hospitals, long term care facilities, and other healthcare institutions under umbrella budgetary control in LHIN coverage areas. The CCACs enter into long term contracts with private and/or not for profit home healthcare agencies that bid for these contracts. The home healthcare agencies are then responsible for providing nursing and professional services to clients (patients) in their homes. Clients may be referred by physicians or by hospitals upon discharge. Case managers from the CCAC and/or the homecare agency evaluate each new client and specify and manage the type and level of care the client is to receive. The home healthcare agency then schedules visits and treatments by its professional staff for the clients as specified by the CCAC, over a prescribed time period.

Supporting chronically ill patients and the elderly in their homes saves approximately $4,000 per person per year that would otherwise be spent on hospitalization and emergency services. Patients who do not receive home visits are much more likely to have to be moved to long term institutional care, costing over $40,000 per person annually. Estimated annual cost for homecare visits is in the neighbourhood of $2,500 per person (Cooly, 2001). It is widely recognized that homecare for the elderly, the chronically ill, and recovering patients is a cost effective way to attack some of the rising cost of healthcare in Canada. At the same time, providing publicly supported homecare has not been found to decrease significantly the amount of informal care provided, particularly to elderly patients (Li, 2005).

The growing availability and use of wireless services (Ipsos-Insight, 2004) and the increased interest in home healthcare has resulted in an innovative project in the introduction of mobile technology to support homecare nurses in Simcoe County, Ontario. The partners in this project are the Simcoe County CCAC, Bayshore Home Health (a homecare agency), Allegro Wireless Inc. (a wireless system development firm), and three departments at McMaster University (DeGroote School of Business, Computing and Software Department in Engineering, and Epidemiology and Biostatistics in Health Sciences). The combination of researchers from

multiple disciplines with a company that specializes in wireless mobility for business, along with two user organizations in the healthcare field, has inspired research into a number of issues that are highly relevant to the improvement of community healthcare productivity and effectiveness.

Through a diary study completed by a number of nurses involved in this study, we have discovered that 52% of their time (not including travel time between visits) is spent on administrative tasks such as communicating, recording, retrieving, and storing information. The data are recorded on paper forms, most of which are communicated to Bayshore support staff and the CCAC by fax. The remaining 48% of nurse time is spent on nursing tasks. It is likely that significant gains could be made in nursing effectiveness by reducing the proportion of time spent on administrative tasks. Since record keeping is currently paper-based, the most efficient way to support these mobile workers appears to be to provide them with wireless mobile handheld devices that would link with central databases, providing instant access to client health and administrative records for downloading, query, and updating purposes.

The objective of this paper is to discuss potential research studies that are relevant to the use of innovative applications of information technology to support community-based home healthcare. In this project, we have identified eight research areas of interest, divided into two major sectors. Those areas lying in sector one where we think research can make a major impact in system development and implementation include: measurement and evaluation techniques in business case research, usability and technology acceptance, system interoperability, and supply chain management. Research in sector two on clinical and administrative decision support for nurses and administrators, and the self management of chronic disease, will await the availability of the production platform and wireless eHealth network that will result from sector one, including the rollout of online production applications to the nursing population.

The general research methodology used in the initial part of this research project, where the system is being planned, designed, developed, and implemented, can be classified as action research. "Action research aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework" (Rapoport, 1970). In action research, the researcher becomes part of the research environment, increasing the likelihood that the environment can be more deeply understood. This can be achieved if the researcher becomes an agent of change in the environment, fostering cooperation and candid information exchange between the researcher and those who are being studied, well beyond what can be expected in traditional research approaches, such as experimental, survey and even case research. This, in turn, can increase the validity of research findings (Kock, Avison, Baskerville, Myers, & Woods-Harper, 1999). Although action research is typically regarded as a qualitative technique, in this research both qualitative and quantitative methodologies are being integrated for model development, data collection, and analysis.

During the second part of this project, where use will be made of the production platform for additional studies in clinical and administrative decision support and for self management of chronic disease, other research methodologies will be used, including positivist comparisons of control and experimental groups that are using innovative practices or processes. In the following, research potential in the eight research areas of interest is described and summarized.

This is followed by a description of the project case and some of the results obtained thus far.

2. HOME HEALTHCARE RESEARCH AREAS

Home healthcare services cover a broad range of services including: ordering and delivering medications and medical supplies, skilled professional and paraprofessional services, personal support services, and providing and supporting medical equipment. Professional services are prescribed mostly by physicians and delivered by homecare nurses or other professionals, either on a visit basis or on a shift basis if continuing care is required. The discussion in this paper will centre on the provision of visiting care by nursing professionals (Registered Nurses and Registered Practical Nurses). Nursing care can be provided for a range of diseases and conditions, e.g. wound care, health assessment, palliative care, pain and symptom management, diabetes teaching, catheter care, and many others. Nursing visits are scheduled in advance, and nurses are provided information about the patient's condition and required treatment. Homecare differs from hospital care, in that the nurse must be prepared to respond to a variety of situations, homes are often remote from professional medical services, and they lack the antiseptic atmosphere and organized range of services provided within a hospital or long term care facility. To develop a system that supports homecare nursing across these categories, and to provide assistance that allows nurses to focus on nursing while easing the burden of administrative work, requires research and innovation in a range of disciplines and areas. Some of these are the focus of this project and are described in the following sections.

2.1 Business Case Analysis

Little attention has been paid to the process of developing the business justification for mobile applications, particularly in eHealth. Both tangible and intangible issues are involved, and these must be addressed in a logical manner, if mobile applications are to be adopted widely. A logical planning process for mobile applications has already been detailed (Archer, 2004), and applying this process to mobile eHealth system planning has also been discussed (Archer, 2005). The outcome of the current work will advance significantly the understanding of mobile systems required for eHealth applications, going beyond quantitative measures such as return on investment, that need to be developed to implement these solutions. Recognized methodologies that can be used to analyze cases and evaluate potential improvements include: cost benefit analysis (Walker, Pan, Johnston, & Adler-Milstein, 2005), best practices (Reijers & Mansar, 2005), and balanced scorecard (Kaplan & Norton, 1996).

2.2 System Design

In healthcare, as in any other industries, processes developed over time for systems are primarily paper-based, and should receive a complete overhaul before the design and implementation of IT solutions. Otherwise an error-prone and inefficient paper-based system may be replaced with an error-prone and inefficient computer-supported system. This overhaul is usually accomplished with Business Process Redesign (BPR), also known as process innovation or business process reengineering. This is defined as "the analysis and design of workflows and processes within and between organizations" (Davenport & Short, 1990). BPR is a maturing concept, and the history of

BPR has involved several phases, some of which in the late 1990s were negative, when management often used BPR as an excuse for massive, arbitrary layoffs. BPR was originally touted as the next revolution in obtaining breakthrough performance via process improvement and change (Champy, 1995; Hammer & Champy, 1993). However, due to the inability of many organizations to realize its scope and resource requirements, BPR often failed to live up to expectations. Some contributing reasons for failure include adoption of a flawed BPR strategy, inappropriate use of consultants, a workforce tied to old technologies, failure to invest in training, a legacy system out of control, IT architecture misaligned with BPR objectives, an inflexible management team, and a lack of long-term commitment (Bergey, Smith, Tiley, Weiderman, & Woods, 1999).

After the original disappointing results from BPR, there have been a number of attempts to develop appropriate models for successful BPR applications, mostly based on in-depth case studies (Broadbent, Weill, & St. Claire, 1999; Clark, Cavanaugh, Brown, & Sambamurthy, 1997; Cooper, 2000) but these approaches have had limited explanatory power. More recently, Paper and Chang (2005) have proposed a comprehensive success factor model for BPR that includes the following components:

- *Environmental success factors:* top management support, risk disposition, organizational learning, teaming, compensation and reward systems, information sharing, and resources.
- *People success factors:* training, education, politics resolution, ownership, and empowerment.
- *Methodology success factors:* appropriate guiding principles, buy-in, direction, continuous monitoring, graphical process map, and customer support.
- *Technology perspective success factors:* IT knowledge, IT belief system, and IT architecture.
- *Transformation or change vision success factors:* vision development, vision communication, vision deployment, and vision flexibility.

These success factor classifications tend to overlap, but they are very helpful in guiding the planning needed to bring out successful business process transformation. Reijers and Mansar have also developed a summary of best practices in BPR (Reijers & Mansar, 2005) that is helpful in identifying and providing improved solutions to process problems. Another flexible approach to exception handling has also been proposed (Wang & Wang, 2006).

2.3 Usability and Technology Acceptance

Crucial elements that must be addressed for any user application are usability and technology acceptance. In particular, mobile applications, no matter how sophisticated, will not be adopted successfully unless the end-users find them easy to learn, easy to use, and helpful in supporting their work. To this point there has been little published research on technology acceptance for mobile devices in the healthcare community. Some very specific issues surround usability of mobile applications due to the limitations of mobile devices, including small screens, constraints on input modalities, battery life, durability, reliable communications access, ruggedness, moisture resistance, and other considerations not encountered in desktop computing. A number of studies have involved the use of wireless handheld devices to monitor clients in remote locations e.g. (Becker, 2005). In addition the use of wireless mobile devices has been explored for the use of physicians for chronic care patients in the home (Maglaveras et al., 2002), and applications of medical wireless systems in accident and emergency wards (Banitsas, Istepanian, & Tachakra,

2002). The positive aspects of wireless systems in clinical applications at the point of care, to reduce errors and other adverse events for in-patient care due to inadequate access to information and ineffective communications have also been explored (Mendonca et al., 2004). Many of these issues have not been considered in detail in the literature, but they must be understood if acceptable interfaces are to be developed. We have presented a conference paper (Wu & Archer, 2005), where the relevant issues were discussed in detail. An experimental evaluation of wireless portal usability has been conducted and will be reported on shortly (Wu, 2005).

Reliable measures of overall usability can only be obtained by assessing the effectiveness, efficiency and satisfaction with which representative users carry out representative tasks in normal environments. The goal of this aspect of our research is to evaluate system usability in the current environment and compare it statistically with usability in the transformed mobile environment. It is critical that the transformed system be at least as usable as the existing system, no matter how compelling the financial aspects of the business case, since ready adoption of an application in a particular situation determines its viability in future installations.

Three phases of evaluation exist (Bevan & Macleod, 1994): expert evaluation; user evaluation; and competitive evaluation. The first evaluators are experts, who apply specialist insight and experience to identify and categorize design errors, and provide certainty about the usability of a design, by observation-based testing. After improvements suggested by the expert evaluators, in the second phase end-users test the user interface design by attempting typical tasks in a real environment. Their feedback will result in system improvements, and this phase may be repeated after improvements are made. The final phase compares the system with the previously used application or with competitive products, against a predefined set of usability criteria, with the potential of enhancing usability to a higher level. In this project, usability and technology acceptance research are supported according to the expressed needs of healthcare providers.

2.4 System Interoperability

The healthcare industry is relatively fragmented, and healthcare information technology has been plagued by an inability to adopt widely accepted standards for medical records and other information that should be shared among institutions, physicians, and other healthcare workers. In addition very few primary care physicians have digitized healthcare record systems[2]. Clients/patients move among healthcare providers as their state of health changes. This creates a need for health records/histories that can move with clients, so each provider does not need to prepare a totally new patient history at admission. Without the general existence of standardized digital health records and some means of system integration or interoperability, individual choice and movement leads to fragmentation of the individual's health care experience, when healthcare providers do not have ready access to client medical history and health information. Typically, client record transfers are accomplished via paper, scanned digital records, and/or fax. The result is that client records may be stored on paper at a number of caregiver institutions or re-keyed into institutional databases, with no possibility of version control, currency, or compatibility. This fragmentation of records often leads to errors, duplication, lack of coordination (Brailer, 2005),

[2] The Chief Technology Officer of the Canadian Medical Association recently estimated that approximately 5% of Canadian primary care physicians use digital client record systems.

conflicting approaches to patient healthcare, service and/or resource duplication and many other problems including reduced quality of care, reduced effectiveness, and increased cost to society.

In Canadian healthcare institutions, both public and private, there is a continuous spectrum of systems, beginning at the more advanced end with major hospitals that tend to have systems to provide online data such as patient admission, status, lab tests, and PACS (Picture Archiving and Communication Systems). In the middle of the spectrum are other private and public healthcare institutions, typically with legacy systems that have no API (Application Programming Interface) capability for developing record interchange support. At the low end of the spectrum are most primary care physicians, with paper files for patient records, and small computer systems for billing and scheduling. If healthcare entities are to exchange records, the institutions with limited or no digital client record systems must make a quantum leap in technology, to be able to provide the necessary interoperability.

At the present time, an interoperability standard HL7 (Gillis, 2005) (currently at version 3), is receiving a great deal of international attention, and standards are either in place or being developed for electronic health records (EHR). The ultimate goal should be to encourage healthcare software vendors to provide a standard HL7 interface with their systems, allowing otherwise incompatible systems to link together for health information interchange. At the same time, progress will move slowly towards the implementation of EHR standards. The HL7 standard is very similar in concept to EDI standards that have been in use for many years by business trading partners in other industries. Sharing healthcare information among entities also requires communication networks with high levels of security and privacy. These safeguards are mandated by legal requirements that have been legislated by the Canadian government (PIPEDA - Personal Information Protection and Electronic Documents Act), and provincial governments (e.g. in Ontario, PHIPA - Personal Health Information Protection Act). If public networks (i.e. the Internet) are to be used, additional safeguards must be in place (firewalls, virtual private networks, etc.) to guard against hacker attack.

2.5 Supply Chain Management

In home healthcare, supplies such as dressings are typically stocked in the home, and a supply of commonly used items is carried by the visiting nurse as emergency backup. Deliveries are usually directly to the home by the supplier on request from the visiting nurse. These supply chain complexities can lead to significant losses due to over- or under-stock and order duplication. Best practices in supply chain management align an organization's internal and external systems with those of its suppliers. Clearly, external interconnections demand interoperability. This improves the flow of products, information, and payments across the supply chain. Difficulties in healthcare supply chains arise from lack of standardization, slowness in implementing technology, and a lack of high quality data upon which to base strategic decisions. Improvements in these areas can lead to better inventory management, fewer losses due to over-ordering or other wasteful practices, enhanced vendor relationships, more satisfied users, and improved quality of care. Improved data can also help in identifying and recalling pharmaceuticals or other products that have been recalled or that have been identified as counterfeit. Group purchasing through arrangements with other major healthcare customers, and the potential use of online healthcare product marketplaces (Archer & Wang, 2004) can also help to reduce costs and improve product choice. Value assessment methodologies can be particularly useful in evaluating changes in

supply chain management processes and their impact on values generated by suggested supply chain improvements in response time (Burn, Caridi, Salama, & Ravelli, 2006).

2.6 Clinical Decision Support

Post and Kagan (1998) have suggested that healthcare has three primary uses for information systems: patient care, transaction processing, and tactical decisions. This project involves all three of these uses, but in this section we will explore the third one, as it applies to clinical applications. Many patients seen by nurses have multiple conditions that necessitate complex decision making. Clinicians need external information to support their care decisions in two out of three patients they encounter (Dawes & Sampson, 2003), and they readily seek information but the available resources have not always been associated with improved patient care (Pluye, Grad, Dunikowski, & Stevenson, 2005). Clinical practice guidelines are "systematically developed statements to assist practitioners and patient decisions about appropriate health care for specific circumstances." (Field & Lohr, 1992). Computerized guidelines provide evidence based recommendations for, and can automatically generate recommendations about, the screening, diagnostic, or therapeutic activities that are suggested for a specific patient. The advantages of computerized guidelines are that they (Sullivan & Wyatt, 2005): provide readily accessible references and allow access to knowledge in guidelines that have been selected for use in a specific clinical context; show errors or anachronisms in the content of a guideline; often improve the clarity of a guideline; can be tailored to a patient's clinical state; propose timely decision support that is specific for the patient and; Send reminders. These approaches can be applied to home healthcare nursing.

In this research, a determination will be made if visiting nurses are able to make use of online clinical information resources, viewed on handheld devices. Patterns of use will also be studied for linkages to improved outcomes. The outcomes will be measured using clinical indicators developed for wound care and other conditions by the Registered Nursing Association of Ontario (RNAO, 2002). Clinical evidence for decision support is available commercially and in handheld formats, although some will have to be migrated to handheld devices.

Another aspect of decision support that is to be explored involves intelligent knowledge discovery in healthcare databases, using intelligent data analysis, with an interactive analysis of data using a subset of techniques based on artificial intelligence. The medical knowledge discovery process (Lavrac, Keravnou, & Zupan, 1997) is an iterative process that includes: understanding the medical domain (data characteristics, fields, distributions), searching the problem space (since medical data are usually incomplete, incorrect, or partly unavailable, and need to be abstracted), using data analysis methods (data abstraction - intelligent interpretation of patient data, or data mining - discovery of new relationships), and interpretation and evaluation of results by an expert who can explain and justify a decision. In designing a software system to make use of this approach, particular attention must be paid to setting up a component-based system that achieves the qualities of extendibility, portability, maintainability, security, and usability.

In the context of a large patient database to exercise this research approach, the data are suitably pre-processed to eliminate references to any individual patients for privacy reasons. Patient data

can be pre-processed into a more suitable format by raising the level of abstraction, data tagging, etc. to allow further knowledge management analysis. This research will begin on research databases provided by a provincial authority, to establish a baseline. The work will then be extended and applied in a real environment to evaluate the impact of additional information on decision making.

2.7 Administrative Decision Support

Paper-based systems provide virtually no information in a form that can be used to generate aggregate reports of value to administrative decision makers. The digitization of information gathered at the source in this eHealth project will create a flood of information that can be harnessed for both administrative and clinical purposes by managers, physicians, and nursing staff, who must make administrative and clinical decisions that affect client welfare and healthcare system operations. The objective or our research in healthcare administrative decision support will be to develop suitable ways of analyzing the data and interpreting the results to assist healthcare providers to make better decisions. The use of standard report generation software can help present certain selected data fields in a manner that is useful for decision making for administrators and clinicians. However, a study of the processes involved in making these decisions, and the impact of additional data to support decision making (Post & Kagan, 1998), will be an important aspect of the research. This will make a substantial contribution to understanding how additional digital information can contribute to an improved healthcare system.

2.8 Self Management of Chronic Disease

Helping the chronically ill to help themselves is an effective method for reducing the cost of the healthcare system without compromising quality of care (examples of non-infectious chronic diseases or conditions include diabetes, hypertension and asthma). Because of the long-term treatment required by chronic illnesses, maintaining adherence (compliance) becomes a fundamental issue in situations which may not allow frequent contact with health providers. Adherence is "the extent to which a person's behaviour - taking medication, following a diet, and/or executing lifestyle changes, corresponds with agreed recommendations from a health care provider" (WHO, 2003). It is seen as a shared medical decision based on a partnership and good communication between patient and provider (Holman and Lorig, 2000).

Adherence (compliance) to a prescribed regimen may be addressed by the use of wireless mobile solutions. Six possible mobile healthcare solutions (monitoring of health parameters, reminding to take a medicine or performing a behavioural change, consulting with health providers, receiving support from family and peers, being informed and educated about the disease and treatment) and their envisioned benefits have been described elsewhere (Cocosila & Archer, 2005). The availability of a wireless platform that will support remote healthcare mobile devices opens up the potential for research in the use of these devices (e.g. cellphones, wireless PDAs) to improve self-management of chronic disease. Three elements that justify the use of mobile solutions to improve outpatient adherence in self-management programs include: location (chronically ill patients are commonly very mobile); utility (continuous contact, monitoring, reminding, and consulting are essential support for many patients); urgency (in extreme cases,

continuous contact with monitoring facilities can either warn of or respond to emergencies). Adherence is a complex phenomenon, and mobile solutions do not automatically improve it. Research on mobile solutions for self-management must be planned and executed carefully, based on extensive examination of factors that can affect adherence, and the use of suitable techniques to counteract factors that can lead to low adherence and reduced treatment effectiveness.

The potential research areas that have been described in the previous sections are summarized in Table 1.

Table 1. Home Healthcare Research Areas

Research Area	Theory	Some Relevant Tools
Business Case	ROI – Improvement in productivity & quality of life; Strategic analysis	Balanced scorecard; Cost/ benefit analysis
System Design	Business process redesign	Process mapping; Process simplification; Interoperability standards; Best practices
Usability and Technology Acceptance	Technology acceptance & related models	Focus groups; Prototyping; Lab & field studies
System Interoperability	Network models; Business models; Policy & economic analysis frameworks	HL7 standard; EHR standards;
Supply Chain Management	Value chain analysis	Workflow; Inventory measurement & analysis; Error analysis; ROI
Clinical Decision Support	Best practices/Evidence based medicine	Expert judgment; Care path models; Focus groups; Field studies; Education
Administrative Decision Support	Optimization models	Scheduling; Risk management; Network, allocation, location models
Self Management of Chronic Diseases	Adherence behaviour; Techology acceptance and adoption	Health eCommunities; Self-help programs; Education; Monitoring; Online support; Reminding; Consulting

3. CASE DESCRIPTON

This project involves the provision of home healthcare nursing by approximately 100 professional nurses working for Bayshore Home Health in Simcoe County, Ontario. The project will proceed in three phases. In Phase One, two application modules were developed (supplies ordering and wound care management) and have completed field acceptance testing. In Phase Two, additional modules will be developed and the system will be rolled out to all the nurses.

After a period of stabilization, studies of decision support will be able to proceed. In Phase Three, additional modules will be developed to complete the project as a commercial product which the developer will be able to implement at other CCACs in Ontario.

The objectives of the research components of this project are:

1) Evaluate effectiveness of business case analysis in providing direction for homecare eHealth projects,
2) Determine the fundamental characteristics of usability and technology acceptance that are relevant to a wireless mobile eHealth project, and evaluate the design and development of prototype applications that are based on optimizing application usability and acceptance,
3) Model and measure the concept of interoperability of multiple systems in a situation where clinical and administrative record standards may not be in place on all the systems,
4) Evaluate the impact of wireless mobile applications in homecare on the effectiveness of medical supplies ordering, in terms of inventory management and reduction in multiple ordering, order errors, duplicate data entry, and delivery intervals.
5) Determine the applicability of the extensive use of medical information in decision support for healthcare administration and clinical management, in terms of identifying issues and patterns, and responding to trends and exceptions encountered by the client care system,
6) Determine the efficacy of wireless applications to support self-management of chronic diseases, with the support of homecare nursing, CCAC activities, training, and education.

In the existing system, information related to client services of any kind is predominantly on paper, except that internal systems at the CCAC and the homecare agencies are used to store client data when it is available in digital form. Very little data actually enters these systems electronically. Instead it is either scanned and stored in image form, or entered manually. The image form of data is useful only for maintaining historical records on individual clients, but it has very little use in supporting and evaluating the general aspects of patient care. Manual entry of digital data from paper forms is limited to essential information that is used primarily for billing, scheduling, and tracking purposes.

An analysis of the business case through a logical process (Archer, 2004) that involved data collection and estimation, has predicted an approximate reduction of 50% in direct (labour and system) costs through the project. In addition, intangible benefits include: delay until data is available to online users reduced from 24 to 0 hours, online availability of data for analysis and decision support increased from 10% to 100%, likely error rate for data entry reduced from 0.20 to 0.05 per data item, homework by home care nurses (faxing and other work) reduced from substantial to minimal, time for client-centred care improved during nursing visits, and time required for routine work reduced. Closure on this part of the research will occur when data are collected on results when the wireless system is rolled out in production mode.

Nursing focus groups were used to gather opinions on various handheld device options, and to gather retrospective views of their experience with prototype applications in the field. A quantitative model was also developed to determine the need for more costly rugged and water resistant handheld devices instead of regular office devices for homecare nurses. Based on a predicted number of incidents that would lead to contaminated, damaged, or failed devices, the additional cost is more than justified, based on a five year life cycle.

The supplies ordering application was first to be developed, and is used here to demonstrate the general approach to system development. This application was selected because it would result in a high return on investment, it would require little if any free text entry, and there was a pressing need to get a fast response to supply orders, as well as to reduce errors and order duplication. Costs of the existing supply ordering system will be compared with costs and savings in the wireless application when the module is online in production mode.

A before and after comparison of the supply ordering business process is shown in Table 2. This is based on a review of the "As-Is" business process with the "To-Be" process, as developed with the aid of the Ben Graham™ process mapping technique. The "To-Be" supplies ordering application includes additional rapid feedback functionality from the supplier, which did not exist in the "As-Is" application. Feedback improves the confidence of the nurses that the supplier will respond to their requests, reducing uncertainty and allowing nurses to focus more on nursing tasks. In addition, many tasks that required manual steps to accomplish in the "As-Is" application have now been automated and proceed immediately to the next step in the "To-Be" revised application, thus greatly reducing the number of time-wasting manual steps and delays in the process. A fragment of the "To-Be" process appears in Figure 1, for illustrative purposes only.

Process mapping is useful for developing a view of complex processes that may involve multiple steps and interconnected branches, and for evaluating proposed improvements. In the table, the largest reductions occur in the number of Handle actions, which involve handling the information (often manual work that could be automated in a digitized system) but not actually changing it. For example, printing or faxing a relevant document is a Handle operation. Transport actions have also been reduced substantially in number. These may involve moving a document from one place to another, such as taking a document home so it can be faxed to headquarters. Storage or Delay actions have also been substantially reduced. The net effect of online supplies ordering is expected to be a large reduction in time delays, coupled with reduction in errors, reduced costs, and improved system user satisfaction.

4. CONCLUSIONS

In this paper, potential research opportunities have been outlined as an adjunct to a major system development project to provide wireless support to home healthcare nurses in Ontario. These opportunities result from action research in project issues such as business case justification, system design, usability and technology acceptance, system interoperability, and supply chain management. Additional research opportunities will follow directly from the implementation of the system platform and related homecare applications, through clinical and administrative decision support and self management of chronic disease.

While this project represents a great opportunity for users, developers and researchers to work together towards a common goal, it is necessary at all times to be cognizant of the risks of IT in healthcare. In particular,

> "the introduction of new technology increases the potential for error, due to computer crashes, data capture anomalies, programming errors, and other failures of automation may replace lost charts, bad handwriting, missing information, and

> other problems experienced with manual systems. Clumsy automation may produce new process problems. If information technology results in more highly coupled systems, failures may increase chances for catastrophes. The widespread use of decision-support technology brings with it the risk of substituting the big blunders of the few for the minor mistakes of the many. Propagating invalid information in decision support technology integrated into EHRs may prompt practitioners to perform inappropriate interventions and harm rather than help patients."(Goldschmidt, 2005).

There is a need to balance the benefits against the risks, and to ensure that risks are identified and mitigated where possible. A great concern of individuals is the privacy, security, and confidentiality of personal health information. With paper records, the possibilities for abuse are limited, but with electronic records they are virtually limitless (Goldschmidt, 2005). As is the case in this project, any IT system developed to support healthcare must undergo a detailed audit by a third party to ensure that security and privacy safeguards are adequate to defend against these risks and satisfy legal requirements.

That said, with the appropriate care in researching, designing, developing, implementing, and evaluating the many facets of this project, we expect that the research will lead to a more accurate, efficient, and effective system of home healthcare delivery that will help to improve home healthcare and the quality of life of citizens, while affording significant economic benefits to society.

Table 2. Process Map Comparison Summary (Number of Actions)[3]

Symbol	Action	Supplies Ordering	
		As-Is	To-Be
	Do	1	0
	Originate	8	9
	Add/Alter	32	30
	Handle	76	21
	Transport	15	5
	Inspect	6	0
	Storage/ Delay	15	6
	Destroy	4	1
Totals		157	72

[3] Charting Symbols and Actions Copyright © 1998, The Ben Graham Corporation. All rights reserved.

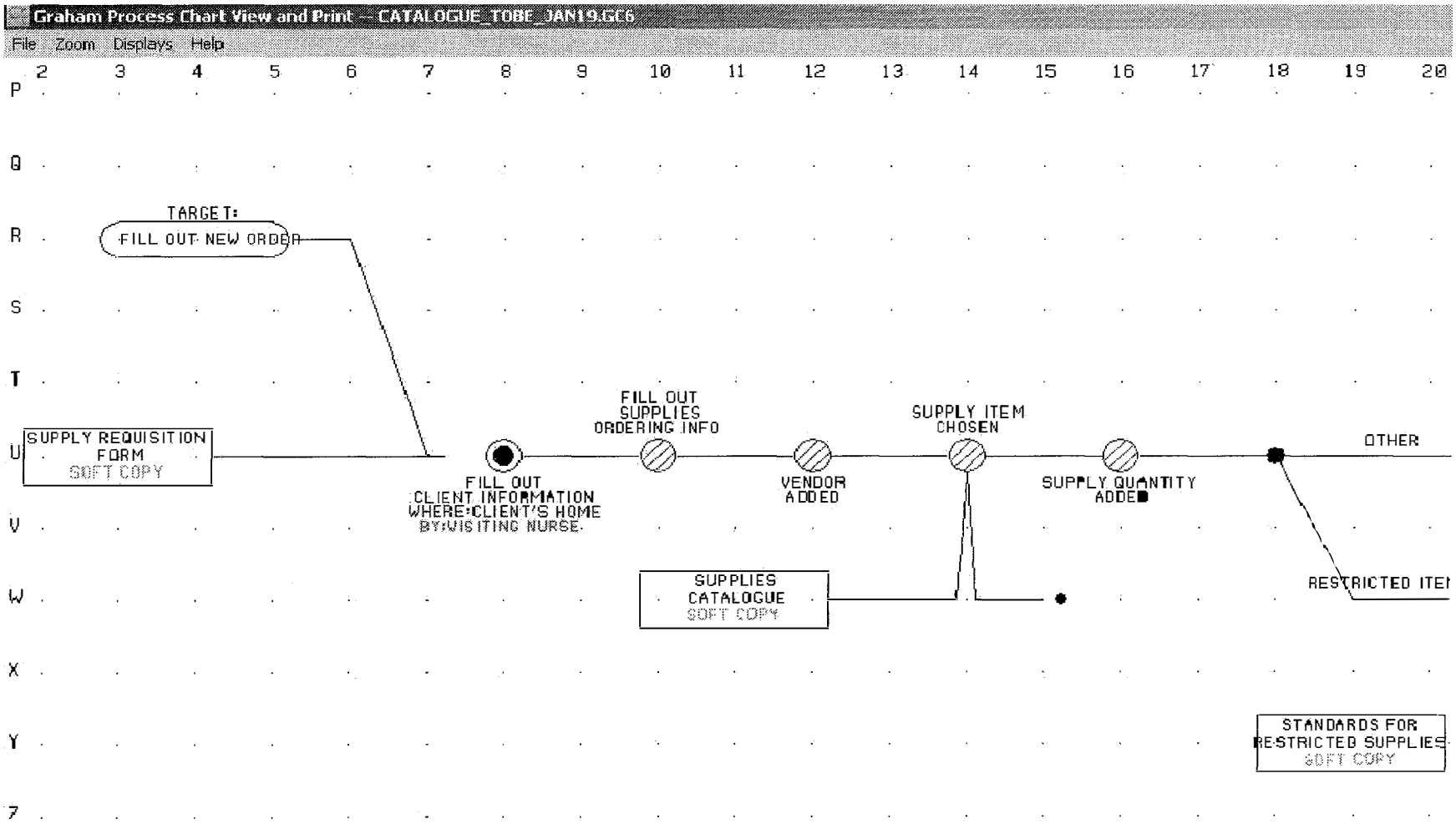

Figure 1. Business Process Map Fragment

REFERENCES

Archer, N. (2004). *The business case for employee mobility support.* Paper presented at the e-Commerce 2004 Conference, Lisbon, Portugal.

Archer, N. (2005, July). *Mobile eHealth: Making the case.* Paper presented at the First European Mobile Government Conference, Brighton, England.

Archer, N., & Wang, S. (2004, December). Electronic marketplaces and the improvement of supply chain practice in healthcare. *Canadian Healthcare Manager.*

Banitsas, K., Istepanian, R. S. H., & Tachakra, S. (2002). Applications of medical wireless LAN systems (MedLAN). *International Journal of Medical Marketing, 2*(2), 136-142.

Becker, S. A. (2005). *Using handheld technology to monitor diabetes in remote communities.* Paper presented at the Managing Modern Organizations Through Information Technology Conference.

Bergey, J., Smith, D., Tiley, S., Weiderman, N., & Woods, S. (1999). *Why reengineering projects fail.* Pittsburgh, PA: Carnegie Mellon Software Engineering Instititute.

Bevan, N., & Macleod, M. (1994). Usability measurement in context. *Behaviour and Information Technology, 13*, 132-145.

Brailer, D. J. (2005). Interoperability: The key to the future health care system. *Health Affairs - From The Field, W5,* W520 - W522.

Broadbent, M., Weill, P., & St. Claire, D. (1999). The implications of information technology infrastructure for business process redesign. *MIS Quarterly, 23*(2), 159-182.

Burn, A., Caridi, M., Salama, K. F., & Ravelli, I. (2006). Value and risk assessment of supply chain management improvement projects. *International Journal of Production Economics, 99*(1/2), 186.

Champy, J. (1995). Reengineering management: The mandate for new leadership. *Industry Week, 24*(4), 32-42.

Clark, C. E., Cavanaugh, N. C., Brown, C. V., & Sambamurthy, V. (1997). Building change-readiness capabilities in the IS organization: Insights from the Bell Atlantic experience. *MIS Quarterly, 21*(4), 425-454.

Cocosila, M., & Archer, N. (2005). A framework for mobile healthcare answers to chronically ill outpatient non-adherence. *Informatics in Primary Care, 13*(2), 145-152.

Cooly, G. (2001). *Home care under attack.* Retrieved January 16, 2006, from http://www.eye.net/eye/issue/issue_07.12.01/news/homecare.html

Cooper, R. (2000). Information technology development creativity: A case study of attempted radical change. *MIS Quarterly, 24*(2), 245-276.

Davenport, T. H., & Short, J. E. (1990). The new industrial engineering: Information technology and business process redesign. *Sloan Management Review, 31*(4), 11-27.

Dawes, M., & Sampson, U. (2003). Knowledge management in clinical practice: A systematic review of information seeking in physicians. *International Journal of Medical Informatics, 71*, 9-15.

Field, M. J., & Lohr, K. N. (1992). *Guidelines for clinical practice: From development to use.* Washington, D.C.: National Academy Press.

Gillis, G. (2005). *HL7 Canada 2004/2005: The year in review.* Retrieved January 21, 2006, from http://secure.cihi.ca/cihiweb/en/downloads/HL7Can_Annual_Report_2004_05.pdf

Goldschmidt, P. G. (2005). HIT and MIS: Implications of health information technology and medical information systems. *Communications of the ACM, 48*(10), 69-74.

Hammer, M., & Champy, J. (1993). *Reengineering the Corporation*. New York: Harper Collins Books.

Ipsos-Insight. (2004). *Promising future for wireless Internet suggested by growth in wireless Internet usage and wireless device ownership*: IPSOS-Reid.

Kaplan, R. S., & Norton, D. F. (1996). *The Balanced Scorecard: Translating Strategy Into Action*. Boston, MA: Harvard University Press.

Kock, N., Avison, D., Baskerville, R., Myers, M., & Woods-Harper, T. (1999). *IS action research: Can we serve two masters?* Retrieved January 20, 2006, from http://ww2.cis.temple.edu/kock/ICIS99/ISARpanel/

Lavrac, N., Keravnou, E., & Zupan, B. (1997). *Intelligent Data Analysis in Medicine and Pharmacology*. Boston, MA: Kluwer Academic Publishers.

Li, L. W. (2005). Longitudinal changes in the amount of informal care among publicly paid home care recipients. *The Gerontologist, 45*(4), 465-473.

Maglaveras, N., Koutkias, V., Chouvarda, I., Goulis, D. G., Avramides, A., Adamidis, D., et al. (2002). Home care delivery through the mobile telecommunications platform: The Citizen Health Citizen (CHS) perspective. *International Journal of Medical Informatics, 68*, 99-111.

Mendonca, E. A., Chen, E. S., Stetson, P. D., McKnight, L. K., Lei, J., & Cimino, J. J. (2004). Approach to mobile information and communication for health care. *International Journal of Medical Informatics, 73*, 631-638.

Paper, D., & Chang, R.-D. (2005). The state of business process reengineering: A search for success factors. *Total Quality Management, 16*(1), 121-133.

Pluye, P., Grad, R. M., Dunikowski, L. G., & Stevenson, R. (2005). Impact of clinical information retrieval technology on physicians: A literature review of quantitative, qualitative, and mixed methods studies. *International Journal of Medical Informatics, 74*, 745-768.

Post, J., & Kagan, A. (1998). Evaluating uses of information technology in health care administration. *Journal of Applied Business Research, 14*(2), 1-10.

Rapoport, R. N. (1970). Three dilemmas in action research. *Human Relations, 23*(4), 499-513.

Reijers, H. A., & Mansar, S. L. (2005). Best practices in business process redesign: An overview and qualitative evaluation of successful redesign heuristics. *Omega, 33*, 283-306.

RNAO. (2002). *Assessment and management of stage I to IV pressure ulcers*. Retrieved January 22, 2006, from http://www.rnao.org/bestpractices/PDF/BPG_Pressure_Ulcer.pdf

Sullivan, F., & Wyatt, J. C. (2005). How decision support tools help define clinical problems. *British Medical Journal, 331*, 831-833.

Walker, J., Pan, E., Johnston, D., & Adler-Milstein, J. (2005). The value of health care information exchange and interoperability. *Health Affairs, 24*, 10-18.

Wang, M., & Wang, H. (2006). From process logic to business logic: A cognitive approach to business process management. *Information and Management, 43*, 179-193.

Wu, X. (2005). *A Usability Study of a Wireless Intranet Portal.* Unpublished Master's Thesis, McMaster, Hamilton, ON.

Wu, X., & Archer, N. (2005). *Usability evaluation to assess transcoding and Web browsing effectiveness: A mobile eHealth proposal.* Paper presented at the World Congress on eBusiness, Hamilton, ON.

MeRC

McMaster eBusiness Research Centre

McMaster eBusiness Research Centre (MeRC)
DeGroote School of Business
McMaster University
1280 Main St. W. MGD A201
Hamilton, ON
L8S 4M4

Tel: 905-525-9140 ext. 27027
Fax: 905-528-0556
Email: ebusiness@mcmaster.ca
Web: http://merc.mcmaster.ca