Outcomes in the Palm of Your Hand

Improving the Quality and Continuity of Patient Care

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# TABLE OF CONTENTS

**MAIN MESSAGES** ............................................................................................................................................. i

**EXECUTIVE SUMMARY** ................................................................................................................................ ii

**PHASE ONE: REQUIREMENTS, DESIGN, TEST PROTOTYPE** ........................................................................... 1
- Setting......................................................................................................................................................... 1
- Sample....................................................................................................................................................... 1
- Approach to Data Collection ................................................................................................................. 1
- Approach to Data analysis...................................................................................................................... 1
- Results..................................................................................................................................................... 1
- Prototype Data Collection and Dissemination System ........................................................................... 2

**PHASE TWO: USABILITY EVALUATION IN LABORATORY** ........................................................................... 3
- Setting..................................................................................................................................................... 3
- Sample................................................................................................................................................... 3
- Approach to Data Collection ................................................................................................................ 3
- Approach to Data Analysis................................................................................................................... 3
- Results................................................................................................................................................... 3
- Discussion............................................................................................................................................. 5

**PHASE THREE: FIELD TEST IN CLINICAL SETTINGS** ................................................................................... 7
- Setting..................................................................................................................................................... 7
- Sample................................................................................................................................................... 7
- Approach to Data Collection ................................................................................................................ 9
- Approach to Data Analysis................................................................................................................... 9
- Results................................................................................................................................................... 9
- Discussion............................................................................................................................................. 16

**LIMITATIONS OF THE STUDY** .................................................................................................................. 17

**NEXT STEPS** ............................................................................................................................................. 17

**REFERENCES** ........................................................................................................................................... 18

**APPENDIX A: ............................................................................................................................................. 19**

**APPENDIX B: ............................................................................................................................................. 23**

**APPENDIX C: ............................................................................................................................................. 24**

**APPENDIX D: DISSEMINATION, LINKAGE AND EXCHANGE ACTIVITIES .................................................. 26**
MAIN MESSAGES

PHASE 1: CONSULTATION WITH NURSES TO INFORM SYSTEM DESIGN

- Hospital and home care nurses wanted ongoing access to electronic drug information, including IV compatibility guidelines. Thirty-nine percent of hospital nurses’ documentation was observed to occur on “personal paper” and later transcribed to a permanent location. This represents a significant opportunity to eliminate duplicate work.

- Hospital nurses were eager for electronic documentation of vital signs, intakes and outputs, and other routine assessments at the point of care.

- Home care nurses currently document at the point of care and want electronic access to policies and procedures.

- Nurses saw value in electronic forms for standard assessments.

- Nurses valued alerts and reminders.

PHASE 2: USABILITY EVALUATION OF PDA AND LAPTOP CONDUCTED IN A LABORATORY SETTING

- Nurses rated PDA usability the same or better than laptop usability in all areas except size and sequencing of screens.

- Nurses wanted to be able to adjust the size of screen characters.

- Instant transmission was important for nurses; waiting 3 or 4 seconds for a network response was not acceptable to most nurses.

- The number of keystrokes needs to be minimized in electronic documentation.

- Nurses wanted to be able to correct data entry errors easily; they liked the ability to save a draft assessment and complete it later in the day.

- Learning how to use a mouse, how to use a stylus and how to use scroll bars were new skills for many nurses. This variety of skills will occur in clinical settings for the foreseeable future, necessitating multi-faceted strategies to facilitate learning.

PHASE 3: FIELD TEST OF THE PROTOTYPE SYSTEM, CONDUCTED IN THREE HOSPITALS AND THREE HOME CARE AGENCIES

- Positive feedback was received from hospital and home care nurses about the prototype system; mean usability scores were all >5 on a 9-point Likert scale with a mean of 7.0.

- Using the device at the point of care can eliminate duplication of documentation if there is real-time access using a secure and reliable network.

- Fast networks with universal access are essential for point-of-care documentation.

- Nurses who accessed the symptom trend graphs reported that they were useful, but many nurses did not view them.

- Nurses did not routinely consult integrated best practice guidelines; presenting patient-specific best practice guidelines at the point of care did not lead to a statistically significant difference in patient/client outcomes.

- The quality and timeliness of staff communication were statistically higher on acute care experimental units than control units.

- Further research is needed to evaluate the effectiveness of the point-of-care decision support system for improving the timeliness and efficiency of information transfer.
EXECUTIVE SUMMARY

This research study seeks to improve the way nurses collect and record patient outcome data, and the access nurses have to health-based data directly at the point of patient care. The study supports an Ontario Ministry of Health and Long-Term Care initiative focused on Health Outcomes for Better Information and Care (HOBIC).

STUDY PURPOSE

The study evaluated the usability of handheld computers; specifically, personal digital assistants (PDAs) for nurses collecting, utilizing and communicating information about patient health outcomes. It also evaluated the feasibility of using PDAs to increase nurses’ access to, and utilization of, best-practice information available electronically to support clinical decision-making.

METHOD

The study was conducted in three phases. The objectives of Phase One were:

- refine existing patient outcome measures for nursing assessment based on an Ontario Ministry of Health and Long-Term Care initiative for better information and care through health outcomes data collection.
  <http://www.health.gov.on.ca/english/providers/project/nursing/nursing_mn.html>

- identify additional types of information that nurses need to collect and access at the point of care through the use of wireless PDA technology.

- develop a prototype information gathering and dissemination system that will provide the software framework for PDA use.

Phase 1 included group interviews and work sampling on medical and surgical units at two acute care hospitals and at two home care organizations. The sample included 35 hospital-based participants and 16 from the home care sector. Data from focus groups, interviews and
work sampling informed the development of a custom prototype system that enabled data entry for HOBIC outcomes, feedback of trend in pain and other symptom scores, presentation of client-specific best-practice guidelines for the management of pain, and prevention/management of pressure ulcers. In addition to the prototype system, each PDA was equipped with an electronic drug handbook and a map resource for community nurses.

The objective of Phase Two was to test the usability of the prototype system with a standardized patient in a laboratory setting. Forty-two nurses participated in the laboratory study: 58 percent worked in hospital settings and 42 percent worked in a home care setting. Participants used both a handheld PDA and a laptop computer to enter outcomes assessment data while assessing a standardized patient (actor) who had learned pre-determined responses to each question. A cross-over design was used, with half of the sample using a PDA first and laptop second, and half of the sample using the laptop first. Participants completed a usability questionnaire following the use of each device. PDA users had online access to client-specific clinical guidelines presented at the end of each assessment, as well as an electronic drug handbook. Laptop users had access to paper versions of the Registered Nurses’ Association of Ontario’s Best Practice Guidelines and a print copy of a popular drug compendium.

The objective of Phase Three was to evaluate the effect of the PDA outcomes application in improving nurses’ communication and their utilization of patient health information in the clinical setting. It also involved an evaluation of the PDA for improving nurses’ access to and utilization of electronically-accessible best practice information, and the effectiveness of PDAs in improving the quality of outcomes for patients. In one hospital, the PDAs were set up as Voice over Internet Protocol (VoIP) phones on the hospital network so that the nurses would not be required to carry two devices. In home care settings, additional resources included order codes for medical supplies and equipment, phone numbers of CCAC staff and quick links to websites such as city maps. The final sample consisted of 176 acute care nurses (44.3% of eligible) and 22 home care nurses (31% of eligible sample). Fifty-nine nurses volunteered to attend a workshop and then field test the prototype system.
Participating nurses used PDAs during a six-month period to conduct the standardized HOBIC data collection. Research assistants conducted assessments on control units in both acute care and in home care in order to be able to compare client outcomes when staff had either access to a PDA or when standard care was provided. A total of 384 hospitalized patients and 159 home care clients participated in the study.
PHASE ONE: DETERMINE REQUIREMENTS, DESIGN AND TEST PROTOTYPE

In the first phase, a cross-sectional design was used to describe nurses’ requirements for Point Of Care (POC) information collection and utilization.

SETTING
The setting for Phase One was medical and surgical units in two tertiary care hospitals in southern Ontario, ranging in bed size from 353 to 472. Both hospitals were in the process of implementing selected components of an electronic health care record. At the time of data collection for Phase 1, nurses were using a paper health care record for recording and accessing patient care information. Computer terminals were available on the units for accessing laboratory test results. The setting also included two organizations which provided home care nursing services where clinical documentation was paper-based and remained in the clients’ homes.

SAMPLE
Although the study planned for a sample of 30 nurses, fifty-one nurses volunteered to participate, 35 from hospitals and 16 from home care. We included all those who volunteered with the goal of providing an opportunity to offer input into the design of the decision-support innovation. The average age of hospital nurses was 38 years (± 10, range 24 to 57 years), whereas the average age of home care nurses was 49 years (± 9, range 32 to 63 years). Ninety one percent of hospital nurses were female and 77% worked rotating shifts. All home care nurses were female and 38% reported that they worked rotating shifts. The nurses in the hospital had on average 13.6 years nursing experience and 5.2 years experience working on the study unit. Only 6% had previous experience with a PDA, primarily for drug reference information, laboratory test values, and personal scheduling, which they used less than weekly. The nurses in home care had on average 23 years experience in nursing and 8.8 years employment with the same organization. Twenty-five percent of the homecare nurses owned a PDA, which they used daily or almost daily.

APPROACH TO DATA COLLECTION
The study received ethical approval from the University of Toronto and the participating hospitals’ research ethics boards. All participants signed an informed consent prior to participating. Data collection on nurses’ information needs and information utilization involved: work sampling of nurses engaged in information access, utilization and transfer; as well as group interviews to identify the type of information nurses need to access and utilize for care-giving decisions. The key findings from the focus group interviews were shared with nurses at the participating sites in order to validate the analysis. The data from the group interviews were used to generate a list of the information needs and resources nurses would like to access on PDAs. Study participants were given an opportunity to prioritize the list by voting for their top 5 priorities. The results of this multi-voting exercise informed the research team about participants’ priorities regarding information access and exchange on PDAs.

APPROACH TO DATA ANALYSIS
A coding scheme was developed to analyze the work-sampling data. Content analysis of the interview data was conducted at several levels by two members of the research team, working independently. Using transcriptions of the group interviews, descriptive codes were identified based on responses to structured research questions about resources that participants indicated would be useful at the point of care, and the types of data that participants indicated they would like to document electronically at the point of care.

RESULTS
Acute Care: Work sampling results revealed that 39% of written information was recorded onto “personal paper” at the point-of-care (POC) and later transcribed into a permanent health record and/or written change-of-shift report. The nurses often sought information
away from the POC; for example, a centrally located health record or electronically accessible patient information (68%), drug dictionary (5.6%), or policy/procedure (1.0%). The most frequent source of information for most staff nurses was “colleagues”, yet not all colleagues are able to offer research-based advice. The resources that nurses would like to access with PDAs at the POC are summarized in Appendix A, Figure A1a and A1b. Nurses’ top priorities for information at the POC included documenting vital signs (72%), accessing information on IV drug compatibility (55%), drug dictionary (48%), preoperative checklist (41%), IV protocols (38%), and alerts/reminders (34%). In the community sector, all of the observed documentation took place in clients’ homes, with telephone calls to confirm appointments with subsequent clients and occasionally to consult with another member of the health care team. Health information was not copied onto “personal paper” for later transcription. The research team did not observe communication that reportedly occurred in the nurses’ homes at the end of the day when they consulted with other health care professionals and colleagues.

PROTOTYPE DATA COLLECTION AND DISSEMINATION SYSTEM

Based on nurses’ requirements to collect core patient data elements and on nurses’ information needs, the research team created a custom software application (see Appendix A, Figure A2) that can be used on any computer. In this study it was used on laptop and handheld computers. It collected and stored patient outcomes data and accessed health information resources that were expected to help nurses select interventions when planning care. The prototype system has four primary functions: 1) wireless data collection of the MOHLTC-selected Health Outcomes for Better Information and Care (HOBIC), 2) provision of real-time feedback about outcomes (see Appendix A, Figure A3), 3) integration of best practice guidelines relevant to particular patient encounters (see Appendix A, Figure A4), and 4) case-based reasoning, which enables users to benchmark a patient’s health outcomes relative to similar patients. The patient/client assessment items included functional status (e.g. eating, bathing, locomotion), symptoms (pain, nausea, dyspnea, fatigue), pressure ulcers, falls, and therapeutic self-care items that elicit a patient’s opinion about how much help they believe they need to manage their health care needs. Initial design of the prototype system was completed and the data collection component was tested by ten nurses using handheld PDAs. A structured debriefing interview was conducted with each nurse. Pilot testing revealed that users found the system useful for collecting and documenting patient information. Enhancements and modifications were made to the prototype, based on feedback from users, prior to Phase 2 of the study.
PHASE TWO: USABILITY EVALUATION IN LABORATORY SETTING

A randomized cross-over design was used to assess the usability of the prototype software system and its impact on nurses’ clinical decision making. Electronic resources and wireless data collection on PDAs was compared to data collection using laptop computers and clinical resources available in paper format.

SETTING
A laboratory setting was used for Phase 2 (Appendix B, Figure B1.) Nurses who consented to participate were randomly assigned to complete an outcomes assessment of a standardized patient (paid actor) and clinical decision-making task either first with the PDA prototype system with electronically-accessible resources, or a laptop computer and paper resources (i.e., drug compendium and RNAO best practice guideline paper tools). Nurse subjects were then crossed-over to complete the same assessment task with either the PDA or laptop, alternating the device used in the first assessment session.

SAMPLE
Forty-two nurses participated in the laboratory study; 58% worked in hospital settings and 42% worked in a home care setting. The nurses ranged in age from 26 to 72 years, with an average age of 44, and average of 16 years of nursing experience. The mean age of 44 is representative of the average age of Ontario nurses. There were 37 female (88%) and 5 male (12%) participants. Two participants had no past experience with a computer. Most participants (93%) had used e-mail and searched the internet; 62% had played computer games.

APPROACH TO DATA COLLECTION
Data collection involved video and audio recording of nurses as they entered patient assessment information and accessed best practice guidelines and drug reference information using the PDA and the laptop. While the participants were entering data, the screen of each device was audio and videotaped using the procedure published by Kushniruk (1996, 1997). In the majority of cases, the PDA was linked directly to a data projector, and the projected image on the wall was recorded. When this was not feasible, in approximately 25% of the cases, the video camera was placed on a tripod behind the participant and the screen of the device was videotaped directly. Immediately following each assessment session, nurses completed a usability questionnaire developed by Norman et al. (1988) at the University of Maryland. The time it took nurses to complete each assessment was recorded.

APPROACH TO DATA ANALYSIS
The audio component of all of the nurses’ interactions with PDAs and with laptops was transcribed, and the videotapes were converted to DVD recordings prior to data analysis. Each videotape was screened in its entirety, followed by detailed documentation of the nature and frequency of data entry errors, time required to complete assessments, and usability issues. Descriptive statistics were used to summarize nurse participants’ responses to the usability questionnaire. Paired t-tests were conducted to assess whether there were significant differences between participants’ satisfaction with entering patient/client assessment information and accessing reference information using the PDA compared to the laptop. Independent t-tests were conducted in order to assess whether there were significant differences in subjects’ responses to the usability questions depending on whether they completed the assessment task first with a PDA or first with a laptop (i.e. second with a PDA.)

RESULTS
Video Recording for Usability Assessment. There were a total of 3700 potential data entry items by acute care nurses. Of these, the analysis of videotapes indicated 102 (0.03%) navigation problems (66 PDA, 36 laptop). The majority of these were related to transitions between items or sections on the outcome assessment tool. We identified 9 display visibility problems of failure in locating a button (5 laptop, 4 PDA). There were 211 (0.06%) recorded failures in clicking on a
button/ menu or selecting an answer or scrolling (187 PDA, 44 laptop), as well as 44 (0.01%) tapping errors that are directly attributable to the laboratory setup and would not occur in a natural setting. This was primarily related to users becoming accustomed to using a stylus for tapping or selecting answers in the PDA application. It is also noteworthy that 24% of participants accounted for 43% of the data entry errors. There were 44 PDA tapping failures related to an intermittent network connection in a single location when participants tapped repeatedly in an effort to retrieve the next question from the server. There were 17 occurrences of selecting a wrong answer (9 PDA, 8 laptop). We recorded 20 occasions on which nurses inadvertently skipped an assessment item (10 PDA, 10 laptop). Among the home care nurses, there were 2500 potential data entry items by home care nurse participants who used handheld PDAs connected to a high-speed cellular network as well as laptops. Analysis of videotaped data entry indicated 92 (0.04%) navigation problems (49 PDA, 43 laptop) primarily related to scrolling and moving to next screens. One participant was a first-time computer and mouse user. A total of 2 display visibility problems were identified, both with the PDA. There were 130 (0.05%) recorded failures in clicking on a button/ menu or selecting an answer or scrolling (105 PDA, 25 laptop). This was primarily related to users becoming accustomed to using a stylus for tapping or selecting answers in the PDA application.

Scores on the usability questionnaire could range from 1 (low satisfaction) to 9 (high satisfaction). All scores are reported in Appendix B, Figure B2. The three highest scored items for the PDA application were: satisfaction with ease of entering patient information (7.9), satisfaction with sharpness of screen characters (7.7), and satisfaction with amount of information on screen (7.6). The lowest scored items were satisfaction with size of screen (6.8), flexibility in entering data (6.2) and satisfaction with helpful error message (4.6) but this last item was deemed not applicable by 21% of users. There were only 2 of the items that hospital nurses scored significantly higher for the laptop compared to the PDA use: satisfaction with size of the screen (8.4 versus 6.9, p<0.01) and satisfaction with the sequencing of screens (7.8 versus 7.1, p<0.05). There were 5 of the items that home care nurses scored significantly more satisfied with the laptop compared to the PDA: satisfaction with size of characters on screen (8.4 versus 7.1, p< 0.01), satisfaction with sharpness of image of characters on screen (8.4 for laptop compared to 7.4 for PDA, p< 0.05), satisfaction with adequate screen size (8.6 for laptop compared to 6.7 for PDA, p< 0.01), satisfaction with power to enter patient information (8.6 for laptop compared to 6.6 for PDA, p<0.01), and satisfaction with system speed (7.9 for laptop and 4.4 for PDA, p<0.01). With regard to the latter two items, it is important to note that nurses in home care used a cellular network for the PDA to access the server and a wired broadband network for the laptop, which could explain the differences in satisfaction scores related to power and speed of the PDA compared to the laptop. These differences will likely be reduced with the advent of broadband cellular networks.

With the exception of one item, there were no significant differences in responses to the usability questions between participants in the PDA first condition and participants in the PDA second condition. This suggests that the order of sessions did not influence subjects’
responses to the Usability questions. The one exception was for subjects in the PDA first condition, who were significantly more satisfied with the ease of correcting data entry mistakes than subjects in the PDA second condition (8.2 versus 6.7, p<.05). This difference could have occurred by chance.

Nurses recorded anecdotal comments about what they liked about the PDA application. Some nurses commented that they liked the focus on one question at a time and they found the PDA easier to use than the laptop computer. Other nurses commented they found the stylus easy to use and appreciated the fact that the PDA would enable them to get closer to patients/clients since it was less intrusive than a computer. Nurses commented they liked the portability of the PDA and found the screen prompts helpful. Hospital nurses appreciated the fact that it was not necessary to “go back to the chart to write answers all over again”.

Some nurses recorded negative comments about the use of the PDA. For instance, nurses found it too time-consuming to log on and enter a password. Some commented critically about the size of the screen, having to tap the screen to enter information, and needing to scroll to see all potential answers to an item.

Time to Complete Assessment Task. The time to complete the clinical decision task was comparable between the PDA (4.45 minutes) and the laptop (4.57 minutes) session. However time to answer the medication question was significantly longer when using the drug reference information on the PDA (2.59 minutes) compared to using a paper drug reference manual (1.82 minutes, p<.05). This difference would likely change in a real-world environment because nurses would typically need to leave a patient’s room to access a drug reference manual at a central location (e.g., nursing station/medication room) whereas they would have access to the PDA resources at the point-of-care. In addition, the study participants were novice users of the online drug resource, having had only a very brief (approximately ten minute) session during a workshop to learn how to look up a drug, but were all experienced users of the CPS drug reference book. It is anticipated that with repeated use, the time to look up a drug using the electronic drug resource would decline.

DISCUSSION
Since study participation was voluntary, it is unknown if participants were typical of colleagues in terms of willingness to try new or innovative technologies. Although a small number of participants had previous experience with PDAs, the majority were novices who learned how to use a handheld device and how to use the prototype assessment tool for the purpose of participating in this study. Learning how to use a mouse, how to use a stylus and how to use scroll bars were new skills for many participants. It can be anticipated that this variety of skill sets will also occur in clinical settings for the foreseeable future, necessitating a variety of teaching strategies. The laboratory study was not entirely representative of a natural clinical setting. For instance research participants were engaged in one clinical decision-making task rather than multiple competing tasks, which is more likely the reality in a clinical setting. Furthermore, there were no interactions among nurses or with family members, and no time pressures while completing the assessment exercise. In addition, the PDA screens were set to a standard font size and brightness for all sessions in order to ensure consistency in the evaluation exercise. In clinical use, users would adjust the font size and brightness on the device to suit their own preference. The PDA electronic resources and paper resources were equally accessible at the point of clinical decision-making. In reality this would not be the case because drug reference manuals are usually stored in a location that is distant from the point of care (POC) whereas electronic drug information is accessible on PDAs at the POC. For this reason, the time to complete the medical question using paper resources in the lab study under-represents the time it would typically require if it were necessary for nurses to leave the patient room to locate a drug reference text in a remote location. In addition, participants were novices at using a PDA-based drug handbook whereas they had expertise looking up medications from paper-based resources.
Based on the videotape analysis of usability issues and the results of the Usability Questionnaire, the following improvements were made to the prototype system:

1. clarified instructions for one question
2. improved links between sections of assessment items
3. re-designed the background colour of the three sections to better demarcate transitions between section
4. added a short-cut, review page option for data entry
5. maintained all items as voluntary for the initial learning period, but future consideration will be given to making select items mandatory in order to ensure quality data.

In addition, the following recommendations were compiled:

1. utilize radio buttons instead of drop-down menus when appropriate in order to reduce the number of key-strokes/taps needed, and ensure that questions remain visible even when drop-down menu appears
2. teach “how to tap” and “how to scroll” with a stylus as unique skills
3. monitor database for quality of data, extent of missing data
4. provide multiple communication channels and vehicles for feedback from users to support team
5. document any point-of-care areas where network or signal strength issues are encountered in settings where PDAs have been tested but not widely used.
PHASE 3: FIELD TEST IN CLINICAL SETTINGS

A quasi-experimental design was used for Phase 3. On experimental units, staff nurses volunteered to learn how to use the PDA-based application and then assessed patients who were being cared for by their team. On control units, a research nurse conducted all of the assessments.

SETTING
This phase of the study took place on a total of twelve medical and surgical units at three acute care hospitals, one of which had not participated in the earlier phases of the study. Each hospital had 350 or more beds. The study also involved three home care agencies which provided home nursing services in one geographic community. One home care agency had not participated in the earlier phases of the study. Clinical documentation at five of the six sites occurred on paper at the time the study was completed, and one acute care site had recently introduced electronic medication administration records. The acute care medical units included cardiology and general internal medicine. The surgical units included gynecology, gastro-intestinal, urology, orthopedic, otolaryngology, oncology, and general surgery services. The number of beds ranged from 26 to 38 with a mean of 31 beds on each unit. Length of stay on the units ranged from 4 days to 12.1 days with a mean of 7.0 days as reported by unit managers. Nurses on the control units were familiar with the study but did not use PDAs or have access to either the PDA-based clinical guidelines or electronic drug handbook that was available to nurses in the experimental group.

SAMPLE
Acute Care Nurses: All nurses employed on study units (n=397) were invited to participate in the study. The final sample consisted of 176 acute care nurses (44.3% of eligible). The hospital participants were predominantly female (92%), working regular full-time (84%), in a staff nurse role (93%). They averaged 41 years of age, with 10 years of experience in their organization, and 6 years on their current unit. On average, they worked 40.54 hours during a typical week. Most nurses in this group (53%) were diploma prepared, 27% had obtained a Bachelor's degree in nursing, 12% were working on a bachelor's degree while 4% had their Master's degree, and 4% had a non-nursing Bachelor's. The nurses on the experimental and the control units were similar in all areas with the exception that members of the control group were two years younger on average and a higher percentage of them (46% vs 40%) had a Bachelor's/Master's degree in Nursing either in progress or completed. The follow-up questionnaire was sent to 155 hospital nurses approximately five months after the intervention was implemented. Twenty-one of the 176 participants no longer worked on study units, and the T2 response rate was 54.2%. Forty-eight acute care nurses volunteered to attend a workshop and field test the prototype system.

Home Care Nurses: All nurses employed by the participating home care organizations (n=72) were invited to participate in the study. The final sample consisted of 22 home care nurses (31% of eligible). The participants were predominantly female (91%), working regular full-time (64%), in a staff nurse role (100%). They averaged 47 years of age, slightly older than the acute care sample, with 6.5 years of experience in their organization, and 4.8 years on their current team. On average, they worked 39.3 hours during a typical week (range 28-50). Most nurses in this group (68%) were diploma prepared (RN or RPN), a larger group than in the acute care sector. The remainder had either obtained a Bachelor's or Master's degree in nursing or were taking courses towards a degree. Eleven nurses (15.3% of all eligible nurses) volunteered to field test the prototype system and attended a workshop to learn to use the PDA. Due to the modest response and the fact that home care nurses work independently and are primarily responsible for their own clients, it was determined that the 11 interested home care nurses would function as the experimental group, regardless of which nursing team they were associated with. The 11 additional nurses who had returned baseline questionnaires were either not interested in participating in the field test or were no longer employed by the agency at follow-up. Any clients being cared for by “non-experimental” nurses became eligible for study participation as control clients.
**Acute Care Patients:** The clinical population included hospitalized people aged eighteen or older and able to provide informed consent in English. They were identified by staff nurses as being admitted for care within the previous 48 hours and expected to remain in hospital for 24 or more additional hours. The 384 participating hospital patients ranged in age from 18 to 95 years with a mean of 55.7, SD 17.3. This represented a response rate of 79.3% of eligible patients who were contacted about the study. A total of 42 patients consented to participate but did not have any data collected because they were transferred off the unit or discharged prior to the admission assessment being completed, yielding an effective participation rate of 86.9%. Fifty-three percent were female. The diagnoses of the patients are presented in Figure 1. Surgical procedures were documented for 208 (54.2%) hospitalized participants. The three most frequent categories of surgeries were genito-urinary (29.8%), musculoskeletal (28.4%), and digestive system (21.6%).

**FIGURE 1: DIAGNOSES OF ACUTE CARE PATIENTS**

**Home Care Clients:** In home care, clients were admitted within the previous 90 days and were expected to receive three or more nursing visits during the study period. There were 159 community clients in the study, of whom 66 (42%) were cared for by experimental nurses. The service recipient categories assigned by the CCAC are presented in Figure 2. The experimental group was over-represented in the categories maintenance and end-of-life care relative to the control group, and under-represented in the remaining groups. This factor was controlled for in the subsequent analysis of client data. The client sample was 54% male, with a mean age of 64.4 years (min 21, max 101, SD 17.8).

**FIGURE 2: HOME CARE CLIENTS, SERVICE CATEGORIES (N=159)**
APPROACH TO DATA COLLECTION
The same approach to data collection was used in both acute care and in home care. Nurse volunteers attended a two-hour workshop to learn how to use a handheld computer and how to use the electronic outcomes assessment tool. The PDA-based system enabled the nurses to enter the outcomes data and to simultaneously receive feedback in the form of line graphs to represent the previous six assessments of pain, nausea, dyspnea and fatigue. In addition, the nurses were presented with best practice guidelines regarding pain management and pressure ulcer prevention and management, which were triggered automatically in response to the patient-specific data. Research staff were available onsite for approximately 35 hours per week to support the nurses who were using handheld computers. Communication vehicles included pagers, phone numbers and e-mail addresses for research staff, written communication log and informal meetings on each unit. Research staff offered to accompany all PDA-users for the first few assessments to support learning to use the device and the assessment tool.

Pre- and post-test data collection included nurse questionnaires to determine if the outcomes assessment affected communication and coordination of care on the units. Both qualitative and quantitative data were collected from participating nurses about their opinions of the PDA and its functions, usability, as well as system interruptions related to either the devices or the communication network. In order to determine if the availability of point-of-care clinical guidelines about pain management and about pressure ulcers had an impact on the documentation of nursing interventions that were identified in the guidelines, nursing documentation was reviewed. Although it is anticipated that nursing documentation may under-represent the interventions that were delivered, the frequency of documentation serves as a proxy indicator for the implementation of nursing interventions.

APPROACH TO DATA ANALYSIS
All patient/client assessment data were encrypted and stored on a secure server. Descriptive statistics are reported to summarize nurses’ responses to the usability questionnaire about the handheld computer, changes in patient outcomes from study admission to discharge, and changes in communication and coordination on the study units. Qualitative data were transcribed and then analysed for thematic content. Inter-rater reliability was conducted, and is reported in Appendix C.

RESULTS
Nurses’ opinions about Usability of Prototype System, Acute Care
On the QUIS usability questionnaire (Norman et al., 1988), twenty-four items were scored on a scale of 1-9, with the five highest and five lowest-scoring items reported in Table 1. Given that ‘5’ would be considered a neutral score, the means for all items were above 5.0 indicating positive feedback in general (see Appendix C).

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean Score (1-9), N=25</th>
<th>min max (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>adequacy of power for entering information</td>
<td>7.7</td>
<td>5 – 9 (1.3)</td>
</tr>
<tr>
<td>consistency of system terminology</td>
<td>7.6</td>
<td>4 – 9 (1.2)</td>
</tr>
<tr>
<td>sharpness of images on screen</td>
<td>7.6</td>
<td>3 – 9 (1.5)</td>
</tr>
<tr>
<td>system speed</td>
<td>7.6</td>
<td>4 – 9 (1.4)</td>
</tr>
<tr>
<td>ease of entering information</td>
<td>7.5</td>
<td>4 – 9 (1.4)</td>
</tr>
<tr>
<td>flexibility for entering information</td>
<td>6.8</td>
<td>1 – 9 (2.3)</td>
</tr>
<tr>
<td>computer keeps you informed of activity</td>
<td>6.7</td>
<td>3 – 9 (1.8)</td>
</tr>
<tr>
<td>satisfaction entering information</td>
<td>6.7</td>
<td>2 – 9 (1.7)</td>
</tr>
<tr>
<td>stimulation entering information</td>
<td>6.5</td>
<td>4 – 9 (1.4)</td>
</tr>
<tr>
<td>helpfulness of error messages</td>
<td>6.5</td>
<td>1 – 9 (2.2)</td>
</tr>
</tbody>
</table>
Nurses’ opinions about Usability of Prototype System, Home Care

Eight of the 11 PDA users returned the final paper questionnaire for a response rate of 73%. This provided data about users’ perceptions of PDA usability, on a 9 point scale (1=low, 9=high). Given that ‘5’ would be considered a neutral score, the means for all items were above 5.0 indicating positive feedback in general. The highest and lowest rated items are reported in Table 2.

TABLE 2: NURSES’ RATING OF USABILITY OF PDAS, HOME CARE

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean Score (1-9), N=8</th>
<th>min max (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ease of entering client data</td>
<td>8.3</td>
<td>7 – 9 (0.9)</td>
</tr>
<tr>
<td>finding or looking up electronic information</td>
<td>8.0</td>
<td>5 – 9 (1.6)</td>
</tr>
<tr>
<td>highlighting on screen</td>
<td>7.9</td>
<td>6 – 9 (1.0)</td>
</tr>
<tr>
<td>image of characters</td>
<td>7.8</td>
<td>6 – 9 (1.0)</td>
</tr>
<tr>
<td>entering information is terrible/wonderful</td>
<td>7.6</td>
<td>6 – 9 (1.1)</td>
</tr>
<tr>
<td>adequacy of power for entering information</td>
<td>7.6</td>
<td>5 – 9 (1.3)</td>
</tr>
<tr>
<td>consistency of messages on screen</td>
<td>6.6</td>
<td>2 – 8 (1.9)</td>
</tr>
<tr>
<td>computer keeps you informed about what it is doing</td>
<td>6.6</td>
<td>2 – 8 (1.9)</td>
</tr>
<tr>
<td>dull/stimulating experience</td>
<td>6.5</td>
<td>3 – 9 (2.0)</td>
</tr>
<tr>
<td>system speed</td>
<td>6.5</td>
<td>3 – 9 (2.1)</td>
</tr>
<tr>
<td>correcting mistakes</td>
<td>5.4</td>
<td>1 – 8 (2.4)</td>
</tr>
</tbody>
</table>

The QUIS Usability scale (Norman et al, 1988) has five subscales, assessing: 1) usability of the PDA for entering information, 2) usability to find information, 3) adequacy of screen display, 4) terminology and system information, and 5) system capabilities. The mean score, range, and standard deviation for each subscale are presented in Table 3.

TABLE 3: USABILITY SUBSCALES, MEAN SCORES ON SCALE 1-9

<table>
<thead>
<tr>
<th>Subscale</th>
<th>Hospital N=25</th>
<th>Home Care N=8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screen (8 items)</td>
<td>Device A, Network A</td>
<td>Device B, Network B</td>
</tr>
<tr>
<td>Mean Min Max (SD)</td>
<td>7.2 3.0-9.0 (1.5)</td>
<td>7.4 6.3-9.0 (1.0)</td>
</tr>
<tr>
<td>System capabilities (2 items)</td>
<td>7.2 4.5-9.0 (1.3)</td>
<td>5.9 2.5-8.0 (2.0)</td>
</tr>
<tr>
<td>Using PDA to find information (4 items)</td>
<td>7.1 4.8-9.0 (1.3)</td>
<td>7.3 5.0-9.0 (1.3)</td>
</tr>
<tr>
<td>Using PDA to enter information (6 items)</td>
<td>7.1 4.3-9.0 (1.3)</td>
<td>7.3 6.2-9.0 (1.0)</td>
</tr>
<tr>
<td>Terminology and system information (6 items)</td>
<td>7.0 4.0-9.0 (1.2)</td>
<td>6.8 4.8-8.0 (1.2)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>7.1 4.8-8.9 (1.1)</td>
<td>7.0 5.6-7.9 (0.9)</td>
</tr>
</tbody>
</table>

Communication: Acute Care

Acute care participants reported that nurse/nurse communication and nurse/healthcare professional communication improved on experimental units during the course of the field test but declined on control units (see Figure 3.) Nurses on experimental units were also more likely to report that they received information in a timely manner when a patient’s condition changed. A variety of intervening factors could have affected staff responses and it is inappropriate to conclude that these changes were solely a result of nurses using the prototype system. A future cluster randomized controlled trial is needed to test the robustness of these findings.
The results of the Analysis of Covariance, assessing differences between the experimental and control acute care units are presented in Table 4.

TABLE 4: COMMUNICATION, ACUTE CARE EXPERIMENTAL AND CONTROL GROUPS

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>F Value</th>
<th>Partial Eta Square</th>
<th>R Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timeliness of information transfer</td>
<td>5.08, p&lt;.05</td>
<td>6%</td>
<td>11%</td>
</tr>
<tr>
<td>General communication</td>
<td>5.28, p=.05</td>
<td>6%</td>
<td>20%</td>
</tr>
<tr>
<td>Teamwork</td>
<td>3.69, p=.06</td>
<td>5%</td>
<td>26%</td>
</tr>
</tbody>
</table>

Communication: Home care

Respondents rated 22 items on a scale of 1 to 5 (1=low, 5=high). There were no significant differences in the home care nurses’ perception of communication over the two points of measurement.

TABLE 5: COMMUNICATION AMONG HEALTH CARE PROFESSIONALS, HOME CARE
(<0.05 WOULD INDICATE SIGNIFICANT CHANGE FROM BASELINE TO FOLLOW-UP.)

<table>
<thead>
<tr>
<th></th>
<th>T1 baseline, N=10 Mean (SD)</th>
<th>T2 follow up, N=8 Mean (SD)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nurse/Nurse</td>
<td>3.81 (1.1)</td>
<td>3.35 (0.5)</td>
<td>0.59</td>
</tr>
<tr>
<td>Nurse/HCP (physician)</td>
<td>3.16 (0.3)</td>
<td>3.50 (0.5)</td>
<td>0.11</td>
</tr>
<tr>
<td>General</td>
<td>3.02 (0.4)</td>
<td>3.08 (0.8)</td>
<td>0.72</td>
</tr>
</tbody>
</table>

Best Practice Guidelines and Intervention Documentation

The majority of acute care nurses (63%) indicated that the RNAO’s Best Practice Guidelines (NBPGs) were available to them, while a larger number of nurses in the control group were unsure (28%) or stated that the guidelines were not available to them (9%). However, the majority of nurses (63%) reported that they had never consulted these guidelines during the past month. Smaller numbers of nurses had consulted the guidelines once (26%), twice (7%), or three or more times (4%) during the past month.
In the home care sector, 19 of 22 participants (86%) indicated that the RNAO’s BPGs were available. Seventeen of the 19 reported that they hadn’t consulted them during the past month.

A chart audit of the documentation of nursing interventions was completed to determine if the presentation of patient-specific best practice guidelines in response to individual patient assessments resulted in a change in the documentation of nursing interventions. The review of documentation related to pain and pressure ulcer interventions, the two outcomes for which intervention guidelines were presented. This review revealed no statistically significant difference between experimental and control units in the acute care setting. Nurses were asked to report the perceived usefulness of the guidelines on a scale of 1 (least useful) to 10 (most useful). Overall experience concerning the guidelines was rated by 16 participants on a likert-like scale (1=not useful; 10 very useful). The scores ranged from 4 to 10, mean 6.2, SD 1.8.

The chart audit also revealed that pain is managed almost exclusively with medications; 63.1% of acute care patients received opioids during their hospital stay. It is also noteworthy that non-pharmacologic interventions were rarely documented (0.8% of cases). It is important to note that very few patients were identified as at risk for pressure ulcers (10.2%). For those patients who had a pressure ulcer, the most frequently documented nursing interventions were: interdisciplinary plan of care (39.5%), referral to occupational therapy (31.6%), position schedule (5.3%), and pressure relieving mattress (5.3%).

A total of 130 home care client charts were audited for evidence of the documentation of interventions based on the best practice guidelines that were embedded in the prototype system. Twenty-nine charts were unavailable to the research team. There was evidence of documentation of two of the ten interventions regarding pressure ulcer prevention or management. There was documented evidence of an interdisciplinary plan of care in 14 charts (6.9% experimental, 3.8% control), and referral to physio or occupational therapy in 7 (4.4%, all control) records. Pain management interventions were documented in 6 of the 130 charts that were reviewed. Opioid use was documented in 4.6% of cases, equally between experimental and control clients. Non-pharmacologic pain management interventions (heat or cold, relaxation, massage, pressure or vibration, and imagery) were documented 5 times (3.8%) in the experimental group and once (0.8%) in the control group.

**Patient Outcomes: Acute Care**

For the variables functional status, pain, nausea, dyspnea, fatigue, pressure ulcers, falls and therapeutic self care, there were no statistically significant differences between the patient outcomes on the experimental units and the control units. There were significant differences between admission and discharge from the study, which is to be expected in an acute care environment.

**TABLE 6: ACUTE CARE, PATIENT OUTCOMES AT DISCHARGE COMPARED TO ON ADMISSION; < 0.05 INDICATES SIGNIFICANCE**

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Mean value (SD) on admission</th>
<th>Mean value (SD) on discharge</th>
<th>t-test (# of pairs)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional Status, ADL</td>
<td>7.54 (7.4)</td>
<td>3.78 (5.9)</td>
<td>8.77 (279)</td>
<td>0.000*</td>
</tr>
<tr>
<td>Therapeutic Self Care</td>
<td>4.04 (0.7)</td>
<td>4.28 (0.7)</td>
<td>-4.83 (284)</td>
<td>0.000*</td>
</tr>
<tr>
<td>Fatigue</td>
<td>4.48 (3.2)</td>
<td>2.92 (2.8)</td>
<td>7.93 (288)</td>
<td>0.000*</td>
</tr>
<tr>
<td>Nausea</td>
<td>1.69 (2.8)</td>
<td>0.94 (2.1)</td>
<td>4.16 (289)</td>
<td>0.000*</td>
</tr>
<tr>
<td>Dyspnea</td>
<td>1.26 (2.4)</td>
<td>0.56 (1.4)</td>
<td>5.20 (288)</td>
<td>0.000*</td>
</tr>
<tr>
<td>Pain</td>
<td>3.97 (3.0)</td>
<td>2.17 (2.3)</td>
<td>9.72 (289)</td>
<td>0.000*</td>
</tr>
<tr>
<td>Pressure Ulcers</td>
<td>0.07 (0.4)</td>
<td>0.05 (0.2)</td>
<td>1.02 (281)</td>
<td>0.308</td>
</tr>
</tbody>
</table>
### TABLE 7: ACUTE CARE, PATIENT OUTCOMES. MEAN SCORES (AND SD) FOR EXPERIMENTAL AND CONTROL UNITS, CONTROLLING FOR BASELINE OUTCOME STATUS, AGE, GENDER, AND LENGTH OF STAY; *< 0.05 WOULD INDICATE SIGNIFICANCE.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Mean score (SD) experiment units</th>
<th>Mean score (SD) control units</th>
<th>Significance*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional Status, ADL</td>
<td>3.18 (5.1)</td>
<td>4.14 (6.3)</td>
<td>0.154</td>
</tr>
<tr>
<td>Therapeutic Self Care</td>
<td>4.31 (0.7)</td>
<td>4.26 (0.7)</td>
<td>0.355</td>
</tr>
<tr>
<td>Pain 2.29 (2.3)</td>
<td>2.09 (2.2)</td>
<td>0.566</td>
<td></td>
</tr>
<tr>
<td>Fatigue</td>
<td>2.91 (2.8)</td>
<td>2.94 (2.8)</td>
<td>0.790</td>
</tr>
<tr>
<td>Nausea</td>
<td>0.70 (1.8)</td>
<td>1.10 (2.2)</td>
<td>0.056</td>
</tr>
<tr>
<td>Dyspnea</td>
<td>0.56 (1.5)</td>
<td>0.55 (1.3)</td>
<td>0.795</td>
</tr>
<tr>
<td>Pressure Ulcers</td>
<td>0.05 (0.2)</td>
<td>0.05 (0.3)</td>
<td>0.624</td>
</tr>
</tbody>
</table>

### Client Outcomes: Home Care

There was a significant improvement in home care clients’ pain, fatigue, dyspnea, instrumental activities of daily living (IADL), and therapeutic self-care between admission and discharge. Analysis of Covariance was run, comparing differences between experimental and control clients, controlling for baseline status on the outcome variable, age, gender, length of stay, and service code. With the exception of fatigue, no statistically significant differences were observed between experimental and control patients for IADL, ADL, Therapeutic Self-Care, pain, dyspnea and nausea. Experimental clients had slightly higher fatigue than control clients at discharge, however for both the groups, the level of fatigue was low and the differences were probably not clinically significant.

### TABLE 8: HOME CARE, CLIENT OUTCOMES AT DISCHARGE COMPARED TO ON ADMISSION; *< 0.05 INDICATES SIGNIFICANCE

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Mean value (SD) on admission</th>
<th>Mean value (SD) on discharge</th>
<th>t-test (# of pairs)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional Status, ADL</td>
<td>3.15 (5.2)</td>
<td>3.05 (6.0)</td>
<td>0.24 (136)</td>
<td>0.815</td>
</tr>
<tr>
<td>Functional Status, IADL</td>
<td>8.72 (6.0)</td>
<td>7.35 (6.6)</td>
<td>2.88 (135)</td>
<td>0.005*</td>
</tr>
<tr>
<td>Therapeutic Self Care</td>
<td>4.25 (0.6)</td>
<td>4.39 (0.6)</td>
<td>-3.22 (125)</td>
<td>0.002*</td>
</tr>
<tr>
<td>Fatigue</td>
<td>3.62 (3.1)</td>
<td>1.96 (2.6)</td>
<td>6.20 (127)</td>
<td>0.000*</td>
</tr>
<tr>
<td>Nausea</td>
<td>0.76 (1.9)</td>
<td>0.48 (1.6)</td>
<td>1.59 (129)</td>
<td>0.113</td>
</tr>
<tr>
<td>Dyspnea</td>
<td>1.39 (2.6)</td>
<td>0.95 (2.0)</td>
<td>2.35 (129)</td>
<td>0.021*</td>
</tr>
<tr>
<td>Pain 2.80 (2.9)</td>
<td>1.72 (2.3)</td>
<td>4.65 (129)</td>
<td>0.000*</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 9: HOME CARE, CLIENT OUTCOMES. MEAN SCORES (AND SD) FOR EXPERIMENTAL AND CONTROL UNITS, CONTROLLING FOR BASELINE OUTCOME STATUS, AGE, GENDER, LENGTH OF STAY, AND SERVICE GROUP; *< 0.05 INDICATES SIGNIFICANCE.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Mean score (SD) experiment units</th>
<th>Mean score (SD) control units</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional Status, ADL</td>
<td>3.17 (7.3)</td>
<td>2.73 (4.7)</td>
<td>0.386</td>
</tr>
<tr>
<td>Functional Status, IADL</td>
<td>6.26 (6.5)</td>
<td>7.79 (6.6)</td>
<td>0.774</td>
</tr>
<tr>
<td>Therapeutic Self Care</td>
<td>4.52 (0.6)</td>
<td>4.33 (0.6)</td>
<td>0.664</td>
</tr>
<tr>
<td>Pain 2.28 (2.3)</td>
<td>1.36 (2.3)</td>
<td>0.387</td>
<td></td>
</tr>
<tr>
<td>Fatigue</td>
<td>2.74 (2.8)</td>
<td>1.55 (2.5)</td>
<td>0.034*</td>
</tr>
<tr>
<td>Nausea</td>
<td>0.60 (1.5)</td>
<td>0.42 (1.7)</td>
<td>0.804</td>
</tr>
<tr>
<td>Dyspnea</td>
<td>0.91 (1.8)</td>
<td>0.90 (2.0)</td>
<td>0.575</td>
</tr>
</tbody>
</table>
Summary of Informal Interviews with Nurse Participants, acute care

Thirty-four nurse participants from the three hospitals participated in the semi-structured debriefing interviews regarding their experience with the prototype system.

*General Comments:* Nurses on the acute care units were generally pleased with using the PDA for collecting data. However, many found the procedure of documenting the assessments on a PDA to be time consuming because they were still required to complete their standard unit documentation. Embedding the outcomes assessment tool into electronic health records would decrease nursing workload and support nursing care plans. It was suggested that the experience would have been more beneficial if documentation directly into the electronic record were possible. Otherwise, the nurses generally found the PDA was easy to use and noted that using the device at the point of care would eliminate duplication.

*The device (display, etc.):* Nurses liked that the device was small and compact, lightweight and could fit in their pockets. A few nurses reported that the screen size was too small, although the median score for this item was 8.0 (on a scale of 1-9) on the quantitative questionnaire. Three of 25 nurses rated the screen size <5 on a 9-point scale. Some found learning how to use the device, particularly the stylus, was difficult, but thought that it would improve with additional practice. Three nurses chose to personalize their PDAs and changed the background display picture or colour scheme on the device they were using.

*Outcomes Assessment Tool (appearance, ease of navigating, etc.):* Generally, nurses found that the assessment tool took some time to get used to, but that with practice, it became easier to navigate through the sections and questions. Some discrepancy in relation to the format/layout of the screens was noted among nurses. Some found the layout quite useful and found it easy to advance to another section while others found the layout “cumbersome” and a “little confusing” with various buttons such as “next”, “back” and “click here”.

*Assessment Tool Content:* Generally, nurses found the content for Functional Status and Symptom management to be good as it enabled them to capture patient data and give feedback about how the patient was progressing. Furthermore, the information obtained from the assessment aided nurses in planning patient care.

*Feedback Module (line graphs):* Many nurses did not use the feedback module which displayed line graphs of the previous six assessments of pain, nausea, dyspnea and fatigue. Those who used the feedback module felt that it was helpful to be able to see how their patients were progressing and to show to the patients.

*Clinical Guidelines:* At the end of each assessment, clinical practice guidelines about pain and pressure ulcers were presented to the user if they were triggered by the individual patient assessment. For example, if a patient was identified as at risk for pressure ulcer by the Braden Scale, or had a Stage 1-4 pressure ulcer documented, selected RNAO nursing best practice guideline for the prevention and management of pressure ulcers were presented. All guidelines generated by the system had point-of-care applicability in terms of planning nursing interventions. Ten nurses reported that they did not read the clinical guidelines on the PDA. Those who did access the guidelines stated that the guidelines were quickly accessible at the end of the assessment. Nurses also commented that the guidelines reaffirmed the nursing interventions they were using and assisted with follow up care. However, some of the more experienced nurses commented that they did not look at or use the guidelines as they already knew them. They thought that the guidelines would be helpful for novice nurses to access, but not relevant for them.

The College of Nurses of Ontario standards regarding the use of restraints was also accessible to PDA users, since it was deemed relevant at the point of care for preventing falls, one of the outcome measures. No PDA users reported that they had accessed this information.

*Network Issues:* The handheld devices relied on each hospital’s 802.11b network to access the server-based assessment tool and database. A total of 14 incidents of being unable to
access the network were reported by acute care nurses over a period of approximately 6 months and approximately 940 data collection episodes (0.01%). Participants at two sites reported no areas of poor connectivity or lost signals, but did report that the logon and authentication took longer than they would like.

Summary of Informal Interview with Nurse Participants, home care

Eleven nurse participants participated in the semi-structured debriefing interview regarding their experience with the prototype system.

General Comments: Nurses in the homecare sector were generally pleased with using the PDA for collecting data. Many found the experience of using the PDA quite enjoyable and convenient; however some found the procedure of collecting the data time consuming. The nurses generally found the PDA easy to use and noted that by using the device at the point of care, charting would be made easier by simplifying documentation.

The device (display, etc.): Nurses liked that the device was small and compact, portable, lightweight and could fit in their pockets. Some nurses found that the screen was clear, but the size and font too small. Some nurses expressed speed as an issue in turning the device on and off. Nurses had not been taught how to adjust the font size or screen brightness during the workshops, and none of them had commented on this challenge to the RAs who could have taught them how to make the adjustments. It is suggested that additional support strategies, such as informal “tap and chat” sessions be provided to staff on a regular basis when new devices are introduced.

Outcomes Assessment Tool (appearance, ease of navigating, etc): Generally, nurses found it easy to navigate through the questions in the Outcomes Assessment Tool. Some nurses had minor technical problems with advancing through the screens from section to section; however, none noted any difficulties with submitting data once an assessment was completed.

Questionnaire Content: Generally, nurses found the questionnaire content to be simple and easy to understand. Some of the nurses suggested that the Therapeutic Self Care questions were confusing for clients; however, no further exploration about this problem was documented. Anecdotal data suggests that nurses customized some of the questions for individual clients.

Feedback Module (Line Graphs of Symptom Scores): The majority of nurses did not use the feedback module, but those who did, felt that it was helpful and useful in clinical practice. One nurse commented that (s)he did not understand the purpose of the graphs, which indicates different learning styles and the need for further education related to the assessment tool.

Use of other functions/features: One nurse used the camera component of the PDA to take photographs of client wounds for documentation and many nurses utilized the drug dictionary.

Clinical Guidelines: Overall experience using BPGs was rated on a scale from 1-10 (1 = not useful, 10 = very useful). The mean score based on responses from 9 participants was 5.8 (range 1-10). Nurses liked that the BPGs were informative, quickly accessible and available when they were needed. Nurses also commented that the guidelines were a good reference resource. None of the nurses commented on what they liked least about the guidelines. Only one guideline, pain management, was reportedly accessed by home care nurses.

Network issues: The home care users accessed the server-based application using a cellular network. There were 5 reported instances out of 420 data collection episodes (0.01%), of nurses unable to access the assessment tool electronically due to an unavailable network connection or an intermittent network connection. Nurses reported that these incidents occurred either in basements or apartment buildings, and in geographic areas that are known to have limited network access.
DISCUSSION

Changing people’s behaviour is a complex process, and making clinical practice guidelines accessible is only one component of a multi-faceted strategy to ensure that evidence-informed practices can be successfully implemented. This project evaluated the utility of an electronic knowledge translation intervention for nurses, utilizing personal digital assistants (PDAs) to deliver evidence-based resources directly at the point of decision making. The study also evaluated the usefulness of PDAs to increase nurses’ collection, utilization, and communication about the Ministry of Health and Long-Term Care HOBIC (Health Outcomes for Better Information and Care) outcomes.

At the time of data collection, none of the study units and home care teams had electronic documentation available to them, although the hospitals and home care agencies were either implementing or planning for future implementation of an electronic health record system. Therefore nurses were generally more familiar with paper documentation than electronic documentation. Nurses in the study had a range of skills and comfort with computers, few had had experience with handheld computers, and it is likely that the nurses who volunteered to participate in the study were those who were more open to electronic documentation. It was noteworthy that in 39% of our observations of nurses’ information exchange, hospital nurses were observed to record information on unstructured paper that they carried in their pockets for later transcription in a central patient record. This 39% represents the opportunity, through electronic POC documentation, for improvement in documentation efficiency and reduction of rework by nurses. Nurses’ priorities for evidence-based resources at the POC were consistent with the kind of resources Royle et al. (2000) identified for nurses in their study. Reference sources and textbooks were the most common. In our study, nurses wanted POC access to drug reference information, intravenous compatibility guidelines, and institutional policies and procedures. Nurses identified the value of having access at the POC to information about specific guidelines related to patient care procedures, such as intravenous push medication guidelines. They identified the need for practice information such as the Braden scale for assessing pressure ulcer risk (Bergstrom et al., 1987), the Morse falls scale for assessing fall risk (Morse et al., 1989), and access to patient education resources. Nursing practice begins with a desire to know and understand each patient. Response to nursing interventions (patient outcomes) is an important component of understanding the patient’s status and progress. McCormack et al. recognized this when they described practice development as a focus on clinical effectiveness, patient outcomes, and evidence-based practice (McCormack et al., 1999). In order to facilitate practice development, we need to create opportunities for nurses to see the relationships between their nursing interventions and their patient outcome achievement. Thus in the prototype software we developed in this study we have imbedded patient outcomes assessment and feedback with electronic access to best practice guidelines in a decision support tool. We posit that outcomes feedback will stimulate nurses to reflect on their practice and motivate them to pursue and adopt evidence-based practice decisions. However, no difference was found between experimental and control units with regard to the documentation of nursing interventions that were consistent with the BPGs. The current study did not explore whether nurses were not following the pressure ulcer prevention and pain management guidelines, or simply were not documenting their interventions. For example, it is possible that the nurses relied on medications as the core strategy for pain management and rarely used non-pharmacologic interventions. Another possibility is that nurses followed various recommendations about non-pharmacologic interventions but did not document their interventions. A multi-faceted strategy is important for operationalizing clinical practice guidelines, including integrating them into the standard workflow and nursing practice, ongoing education, and integrating guidelines into the documentation process. Presenting knowledge to nurses at the point of care is not sufficient in isolation of additional strategies. The nurses in this study reported that the PDA was useful for collecting health information about patients/clients. Hospital nurses in particular, found the size of the PDA and portability useful for point-of-care documentation. They were highly satisfied with the ease of entering patient information, with the sharpness of the image on the PDA screen, with the amount of

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information display and screen layout. In the acute care setting there was a significant
difference in the timeliness of information transfer, in general communication, and team
communication between experimental and control units, controlling for baseline differences.
These promising results need to be tested for robustness in a future cluster randomized
control trial, with a larger number of inpatient units and practice settings. It would be
premature to attribute causal inference to the findings in this study, and it is possible that
the Hawthorne effect might have contributed to some of the observed differences between
the experimental and control units.

The decision support application developed in this study supports the Ministry of Health and
Long-Term Care Health Outcomes for Better Information and Care (HOBIC) initiative. The
case-based reasoning application is designed to specifically address nurses’ use of the HOBIC
outcomes information at the point-of-care to inform clinical decision making. The kind of
use that was developed in this study is essential to meaningfully engage nurses in the outcomes
data collection. Future development needs to focus on expanded functionality, always working
with nurses as the end-users to design case-based applications that support their work flow
and clinical decision making.

Some of the nurse users in this study self-taught themselves about additional features of the
PDAs such as using the camera to take pictures to monitor wound care outcomes and using
the internet to look up additional resources; others chose to use the PDAs only for the specific
research study purpose. In a future study, we would encourage the addition of informal,
scheduled “tap and chat” sessions for research staff to host drop-in technical assistance, to
teach users about additional features of the devices.

LIMITATIONS OF THE STUDY

The study did not include clients who were cognitively impaired or whose English language
skills prevented them from being able to provide informed consent. Critically ill patients/clients
are likely under-represented if they were deemed by their primary nurse to be too ill to be
approached about participating. The study design enabled an evaluation of the usability of
the prototype system. In addition, a strength of the study was engagement of nurses in the
development and refinement of the system in phases one and two of the study. However,
further research is needed to establish the costs and benefits of the prototype system.

NEXT STEPS

The requirements for electronic interface have been investigated. A proposal to conduct a
market analysis study to determine the best approach for marketing the prototype system to
health care organizations (e.g. directly or through vendor partnerships) has been submitted to
the Ontario Centres of Excellent (OCE). Depending on the results of the market analysis study,
Dr. Doran will apply to OCE for a Market Readiness grant to be geared towards re-architecting
the software so that it can be upgraded to a commercial grade product that could interface
with any electronic health record system. In addition, selected elements of the user interface
need to be redesigned.

Additional research opportunities include:

- Explore the value of providing nurses with different types of electronic resources at the
  point of care
- Explore health care team communication and continuity of care after outcomes data are
  integrated with current documentation and are electronically accessible
- Explore the use of new devices for use at the point of care in health care settings
- Conduct a cost benefit evaluation using a cluster randomized control design.
REFERENCES


APPENDIX A

FIGURE A1A: RESOURCES NURSES WANT AT POINT-OF-CARE, HOSPITAL SECTOR

FIGURE A1B: RESOURCES NURSES WANT AT POINT-OF-CARE, HOME CARE SECTOR
FIGURE A2: ARCHITECTURE OF THE HEALTH OUTCOMES SERVER

FIGURE A3: GRAPHICAL DISPLAY OF SYMPTOM SCORES
FIGURE A4: INTEGRATION OF PRACTICE GUIDELINES WITH POINT-OF-CARE ASSESSMENT DATA

First, the Braden Scale is initiated on the Outcomes Assessment Tool.

Next, the system finds and presents the first few words of relevant recommendations.

Second, the score is calculated by the system.

Finally, the nurse can choose to see a complete recommendation.
PROTOTYPE DATA COLLECTION AND DISSEMINATION SYSTEM

Based on nurses’ requirements to collect core patient data elements and on nurses’ information needs, the research team created a custom software application. The Health Outcomes Server is a prototype web-based application designed for use by nurses at the point of care. The system could be used on any computer. In this study it was used on laptop and handheld computers. It collected and stored patient outcomes data and accessed health information resources that were expected to help nurses select interventions when planning care. Initial design of the prototype system was completed and the data collection component was tested by ten nurses using handheld PDAs. A structured debriefing interview was conducted with each nurse. Pilot testing revealed that users found the system useful for collecting and documenting patient information.

The prototype system has four primary functions: 1) wireless data collection of the MOHLTC-selected Health Outcomes for Better Information and Care (HOBIC), 2) provision of real-time feedback about outcomes (see Figure A3), 3) integration of best practice guidelines relevant to particular patient encounters, and 4) case-based reasoning, which enables users to benchmark a patient’s health outcomes relative to similar patients. Almost all items are completed by tapping or selecting choices from drop-down menus. There are data items for assessing functional status (e.g. eating, bathing, locomotion), symptoms (pain, nausea, dyspnea, fatigue), pressure ulcers, falls, and therapeutic self-care items that elicit a patient’s opinion about how much help they believe they need to manage their health care needs. Data entry is organized by tabs corresponding to these categories, as seen in Figure A5.

FIGURE A5: DATA CATEGORIES AND DISPLAY
APPENDIX B

FIGURE B1: PHASE 2 USABILITY LAB SETUP

Nurse and Standardized Patient; laptop or PDA connected directly to data projector

AV technician

Videotapes copied to DVDs prior to data analysis

FIGURE B2: USER SATISFACTION WITH PDA IN LAB SETTING

- Ease of entering patient information: 7.9
- Sharpness of screen characters: 7.7
- Amount of information on screen: 7.6
- Helpfulness of screen layouts: 7.6
- Helpfulness of highlighting on screen: 7.5
- Ease of correcting errors: 7.5
- Adequacy of screen size: 6.8
- Flexibility to enter data: 6.2
APPENDIX C

PHASE 3, INTER-RATER RELIABILITY: PATIENT /CLIENT ASSESSMENTS

Acute Care: Research staff conducted 36 assessments with study nurses for the purpose of determining inter-rater reliability. Correlation on 9 assessed functional status items ranged from 0.876 to 1.0, and intraclass correlations on these items ranged from 0.93 to 1.0. For one item (continence), the assessors agreed on 34 of 36 cases; the correlation was 0.37 and the intraclass correlation was 0.42. The time frame for the continence item appears to have caused confusion, since having a catheter at any time in the past 24 hours would count as “continent with catheter” even if the catheter was not present at the time of the assessment, information that might not have been sought out or known to all assessors. Research staff also conducted 32 parallel reviews of the documentation of nursing interventions, with agreements of 95.6% of interventions related to the prevention or management of pressure ulcers and 99.0% of interventions related to the management of pain.

Home Care: Research staff conducted 11 assessments for the purpose of determining inter-rater reliability. Correlations for 17 assessed items ranged from 0.84 to 1.00 and intraclass correlations ranged from 0.80 to 1.00. For one item (continence), the correlation was 0.025 and the intraclass correlation was 0.006 (CI -0.57-0.58); there was 91% agreement between assessors. For the item about wheelchair use, the correlation was 0.67 and the intraclass correlation was 0.64 (CI 0.11-0.89), with 91% agreement between assessors.

PDA USABILITY EVALUATION, PHASE 3 FIELD STUDY

<table>
<thead>
<tr>
<th>Item (scale 1-9)</th>
<th>Hospital n=25 Device A, Network A</th>
<th>Home Care n=8 Device B, Network B</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mean Min Max (SD)</td>
<td>Mean Min Max SD</td>
</tr>
<tr>
<td>Using PDA to enter patient/client information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terrible – wonderful</td>
<td>7.0 4-9 (1.3)</td>
<td>7.6 6-9 (1.1)</td>
</tr>
<tr>
<td>Frustrating – satisfying</td>
<td>6.7b 2-9 (1.7)</td>
<td>6.9 4-9 (1.6)</td>
</tr>
<tr>
<td>Dull – stimulating</td>
<td>6.5b 4-9 (1.4)</td>
<td>6.5 3-9 (2.0)</td>
</tr>
<tr>
<td>Difficult – easy</td>
<td>7.5a 4-9 (1.4)</td>
<td>8.3a 7-9 (0.9)</td>
</tr>
<tr>
<td>Inadequate power – adequate power</td>
<td>7.7a 5-9 (1.3)</td>
<td>7.6 5-9 (1.3)</td>
</tr>
<tr>
<td>Rigid – flexible</td>
<td>6.8b 1-9 (2.3)</td>
<td>7.4 4-9 (1.7)</td>
</tr>
<tr>
<td>Subscale total</td>
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<td>7.3 6-9 (1.0)</td>
</tr>
<tr>
<td>Using PDA to find information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terrible – wonderful</td>
<td>7.0 3-9 (1.6)</td>
<td>8.0a 5-9 (1.5)</td>
</tr>
<tr>
<td>Frustrating – satisfying</td>
<td>6.9 4-9 (1.5)</td>
<td>6.7 4-9 (1.8)</td>
</tr>
<tr>
<td>Dull – stimulating</td>
<td>6.9 4-9 (1.5)</td>
<td>7.5 5-9 (1.4)</td>
</tr>
<tr>
<td>Difficult – easy</td>
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<td>8.0a 7-9 (0.9)</td>
</tr>
<tr>
<td>Subscale total</td>
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<td>7.3 5-9 (1.3)</td>
</tr>
<tr>
<td>Screen / display</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size of screen inadequate – adequate</td>
<td>7.2 2-9 (2.1)</td>
<td>6.6b 1-9 (2.6)</td>
</tr>
<tr>
<td>Characters on the computer screen hard to read – easy to read</td>
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<td>7.4 4-9 (1.8)</td>
</tr>
<tr>
<td>Size of characters inadequate – adequate</td>
<td>7.1 3-9 (1.8)</td>
<td>7.1 4-9 (1.7)</td>
</tr>
<tr>
<td>Image of characters fuzzy – sharp</td>
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<td>7.8a 6-9 (1.0)</td>
</tr>
<tr>
<td>Highlighting on screen unhelpful – helpful</td>
<td>7.4 3-9 (1.8)</td>
<td>7.9a 6-9 (1.0)</td>
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<tr>
<td>Screen layout helpful never – always</td>
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<td>7.4 6-9 (0.9)</td>
</tr>
<tr>
<td>Amount of information on screen inadequate – adequate</td>
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<td>7.5 6-9 (1.1)</td>
</tr>
<tr>
<td>Sequence of screens confusing – clear</td>
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<td>7.3 6-9 (0.9)</td>
</tr>
<tr>
<td>Subscale total</td>
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<td>7.4 6-9 (1.0)</td>
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</table>

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<table>
<thead>
<tr>
<th>Item (scale 1-9)</th>
<th>Hospital n=25 Device A, Network A</th>
<th>Home Care n=8 Device B, Network B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Min Max (SD)</td>
</tr>
<tr>
<td>Terminology and system information</td>
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<td></td>
</tr>
<tr>
<td>Use of terminology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>inconsistent – consistent</td>
<td>7.2</td>
<td>4-9 (1.2)</td>
</tr>
<tr>
<td>Terminology relates well to work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>never – always</td>
<td>6.8b</td>
<td>3-9 (1.6)</td>
</tr>
<tr>
<td>Messages on screen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>inconsistent – consistent</td>
<td>7.6a</td>
<td>4-9 (1.2)</td>
</tr>
<tr>
<td>Messages on screen confusing - clear</td>
<td>7.3</td>
<td>4-9 (1.3)</td>
</tr>
<tr>
<td>Computer keeps you informed about what it is doing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>never – always</td>
<td>6.7b</td>
<td>3-9 (1.8)</td>
</tr>
<tr>
<td>Error messages unhelpful - helpful</td>
<td>6.5b</td>
<td>1-9 (2.2)</td>
</tr>
<tr>
<td>Subscale total</td>
<td>7.0</td>
<td>4-9 (1.2)</td>
</tr>
<tr>
<td>System Capabilities</td>
<td></td>
<td></td>
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<tr>
<td>System speed too slow – fast enough</td>
<td>7.6a</td>
<td>4-9 (1.4)</td>
</tr>
<tr>
<td>Correcting mistakes difficult - easy</td>
<td>6.9</td>
<td>4-9 (1.5)</td>
</tr>
<tr>
<td>Subscale total</td>
<td>7.2</td>
<td>5-9 (1.3)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>7.1</td>
<td>5-9 (1.1)</td>
</tr>
</tbody>
</table>

a highest scoring items; b lowest scoring items in each sector
APPENDIX D: DISSEMINATION, LINKAGE AND EXCHANGE ACTIVITIES

Both formal and informal dissemination of study progress has occurred to date. Communication strategies were developed to ensure communication not only among team members, but also with the broader stakeholder group of project supporters.

- WebCT was used as a vehicle to enable members of the research team to share documents such as literature reviews in a manner that is more secure than e-mail, using a bulletin board format.
- Linkages were made with multiple departments at each participating site, specifically nursing informatics, IT, infection control, pharmacy, as well as nursing management. Meetings were held with software, network and PDA manufacturers in order to be informed about current and upcoming technologies.
- Presentations/Publications (funding support acknowledged at each presentation):
  - Newsletter item: @NIT, Issue 7, Spring 2005 “Breaking Down the Barriers to Interdisciplinary Research; Outcomes in the Palm of Your Hand”. Toronto: Nortel Institute for Telecommunications at the University of Toronto.
  - Profiled at the “Nursing and Health Outcomes Project” invitational symposium March 8 2005, Toronto.
  - Doran, D., Mylopoulos, J. et al., July 13 2005. Sigma Theta Tau International, Evidence-Based Nursing Pre-conference, Hawaii
  - Knowledge Transfer Rounds, University of Toronto, November 2005. Outcomes in the Palm of Your Hand: Linking Real Time Feedback, Case-Based Reasoning, and Evidence-Based Practice through Point-of-Care Technology.
  - Ministry of Health and Long-Term Care, December 12 2005. Outcomes in the Palm of Your Hand: Linking Real Time Feedback, Case-Based Reasoning, and Evidence-Based Practice through Point-of-Care Technology.
  - Invited by Nortel to present at the HIMSS conference in San Diego, February 2006.
  - Doran, D. M. and Carryer, J. Outcomes in the Palm of Your Hand; Outcomes and Health Information Technology at the Point of Care. Nursing Students of Ontario, an RNAO Interest Group, Nursing Student Summit, Toronto, ON, April 29 2006.
- “Outcomes in the Palm of Your Hand” Article in *Shaping the future of Nursing*, a publication of the Registered Nurses’ Association of Ontario.


