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Hand-held computer technology for capture of routine perinatal data

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Design and application of handheld computer technology to the electronic capture of routine perinatal data

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Abbreviations and definitions used

AC	Alternating current power supply
ANOVA	Analysis of variance
BASIC	Beginners All-purpose Symbolic Instructional Code; a computer programming language
C.I.	Confidence interval
CDN	Canadian dollars
Database	A collection of records; this use of this term is equivalent to Microsoft Corporation's definition for the term 'table' and should not be confused with Microsoft Corporation's use of the same term.
DOS	Disk Operating System; specifically, the Microsoft disk operating system
EPOC	An operating system used in Psion mobile computing devices.
Field	A single piece of information in a given database; also called a variable
IT	Information technology
LoPHID	Local Public Health Infrastructure Development Project
LPN	Licensed Practical Nurse
MS	Microsoft
Object-oriented	Features of a system that allow users to manipulate different types of objects
ODBC	Open Database connectivity; a standard database access method developed by Microsoft Corporation that allows users access any

	data from any application, regardless of which database management system is handling the data
OPL	Optimisation Programming Language
OR	Odds ratio
OS	Operating system
PC	Personal computer
PCR/PCR 1.0	Post-partum Client Record, Version 1.0
PHN	Public health nurse
QWERTY-style	The arrangement of keys on a standard English computer keyboard or typewriter.
Record	One complete set of fields in a given database
RN-Diploma	Registered nurse - Diploma level
RN-Baccalaureate	Registered nurse - Baccalaureate level
RN-Masters	Registered nurse - Master's degree.
USD	U.S. dollar
VBA	Visual Basic for Applications; a version of the BASIC programming language designed for use in applications such as MS Access 2000 that offers a number of object-oriented features

Abstract

In Nova Scotia's Eastern Region, Public Health Services replaced existing perinatal forms with an electronic data capture system. Piloted between March-June 2000, this Postpartum Client Record (PCR) system involved the use of handheld computers to replace paper forms. Measurement of nurses' attitudes towards using computers before and after the pilot period showed a majority of respondents feel receptive to the integration of computers, although responses to specific attitudinal statements related to: experience with computers, age, educational background, year (date) most recent degree was received and possession of a home computer. Analysis of PCR data compared with data from two other sources revealed good data quality (sensitivity = 0.83), some opportunity for further improvement. Although cost analysis found PCR slightly more expensive than the existing paper-based system, potential benefits for organisational and health system planning favour its implementation. The researcher concludes with recommendations and describes the design of two other handheld applications.

Summary

Public Health Services introduced an electronic data capture system involving palm-size, handheld computers to improve perinatal information management in the Eastern Region, Nova Scotia. Over a pilot period of three months, the Post-partum Client Record (PCR) system replaced conventional, public health nursing paper forms with electronic forms contained on handheld and desktop computers. Successful demonstration of the integration of handheld computers into routine public health data collection carries both national and international implications for health information management.

The research intended to: describe the development of the pilot computerised information system; measure and assess changes in attitudes towards computer use and perception of perinatal information management; compare quality of data collected by the system with that of other sources; assess cost, ethics and acceptance of the system by its users; and formulate recommendations for future implementation.

A wide variety of health related applications have used handheld computers, including: survey field work, clinical studies, aid for clinical decision-making and home care nursing. Information system design and implementation must consider the ethical implications of how handheld computers are used to ensure client confidentiality is protected. To produce data for analysis, the pilot system de-linked client data from personal identifiers for analysis using an automated encryption technique. Password security mechanisms protected handheld computer data from unauthorised viewing.

Initial pilot system development occurred in coordination with database content development, both under the advisement of an inter-disciplinary planning committee. User feed back and suggestions led to the development of subsequent versions of the piloted system, each taking into account the problems of the previous version.

A number of handheld hardware, software and implementation issues emerged during the pilot study. Users found handheld computer screens difficult to read in poor light conditions and slow to display the next/previous screens. Some users found the experience of completing an electronic form time consuming and difficult to manage without compromising their interaction with their client. To address these issues, recommendations for the design and implementation of future Electronic Data Capture systems include:

- selecting a handheld computer with a faster processor speed and screen with greater transmissive properties;
- overlaying handheld screens with clear plastic sheets to protect screens;
- considering a number of specific development measures to improve the speed and responsiveness of handheld forms;
- using several specific techniques to decrease the time required to transfer data and forms to/from handheld computers;
- identifying information management needs before selecting the appropriate desktop software
- allotting a longer period (6-12 month) for implementation that

incorporates a formal technical support mentor system and measures to ensure nurses become proficient at using the pilot system.

In considering the impact of the pilot system on users, public health nurses completed a questionnaire on attitude towards computers and perceptions of perinatal information management in daily practise before and after the pilot study. Public health nurses not involved with the pilot study also completed questionnaires to serve as a contrast group for attitude and perception changes after the pilot study.

Concerning perceptions of perinatal information management, analysis detected only one difference between pre-pilot and post-pilot period median responses. Pilot system users were more likely to decrease their belief that perinatal information is always accurate following the pilot study, compared with non users (Wilcoxon Signed Rank Test p-value=0.036).

Analysis also found no difference between non-pilot and pilot study participant responses to individual statements. The researcher detected a change in overall attitude towards computers: the median attitude towards computer score of pilot system users was lower after the pilot study, compared with the median pilot system user score before the study (Wilcoxon Signed Rank Test, p-value<0.01). In contrast, non-pilot system user responses showed no difference.

Overall, the median response to statements pertaining to training suggest respondents felt they did not receive sufficient quantities of training or training in a timely manner for their current computer system.

The findings of this section suggest changes to the approach, organisation and timeliness of training. Implementers should consider the ratio of staff-to-computers before more computer-related tasks are to be completed, given the existing number and organisation of computers in each office. Future implementation strategies should promote both the measures taken to ensure client confidentiality and positive benefits of new computer applications or systems to the user and client. Future trainers should also consider the views of users defined by experience with computers, age, educational background, year (date) most recent degree was received and possession of a home computer.

The researcher compared data collected using the pilot system with information from two other sources: the findings of an in-house chart audit and data from an existing hospital-based system.

Comparison of pilot system data with data from the existing paper format system was not conclusive, due to a low number of comparable measures. Future comparison should employ a greater number of comparable measures to better understand differences in data quality and completeness of data collected by the pilot and existing paper-based systems.

A detailed comparison of pilot system data with data collected via the Reproductive Care Program's hospital-based Atlee system involved 23 data elements collected by both systems. A comparison of records in the two data sets revealed a considerable difference in the number of infants recorded in the two systems' databases. Several plausible explanations for this difference include:

- the subset of the Atlee database analysed excluded mothers who live in the service catchment of pilot study offices but gave birth outside Cape Breton Complex hospitals (e.g. IWK Grace Hospital in Halifax);
- the pilot study data set excluded mothers who gave birth at a Cape Breton Healthcare Complex hospital but lived outside the service catchment;
- mothers and infants assessed as healthy and not requiring further care, or clients who refused further contact may not have been entered into the pilot study system; and
- despite having an established referral system for hospital discharged mothers and newborns, public health nurses may not have received a discharge referral form from the hospital for some mothers.

Among client records matched by unique identifiers, the pilot system variable sensitivity score measured slightly lower ($\bar{x}$=0.83) than the RCP information system ($\bar{x}$=0.91). The researcher also detected a higher proportion of completed RCP client record data elements, compared with pilot system data elements (Chi-squared test for proportions p-value=0.0039). Considerable opportunity exists for improving the pilot system's potential for screening mothers requiring public health followup.

Based on the findings, the researcher made the following recommendations:

- public health review practise guidelines for early post-partum identification and referral to ensure documented contact with *all* mothers.
- Public health commit additional training towards the review and clarification of public health practise expectations for assessing and entering data elements.
- Following implementation of the above recommendations, conduct a similar data comparison to determine if data quality has improved.

Cost analysis favours the implementation of an electronic data capture system in Eastern Nova Scotia. An analysis of quantifiable costs and potential savings of the PCR system compared with the existing paper format system suggests quantifiable costs outweigh savings of the PCR system by approximately one thousand dollars.

Additional not easily quantifiable long-term costs and potential savings include: (1) the reduction of paper usage and record storage space (2) greater user experience with both the PCR system and new format structure/content; (3) the increasing afford-ability of handheld hardware and software; (4) costs associated with introducing changes or modifications to the existing PCR system; (5) costs associated with technical difficulties. Although difficult to ascertain a specific amount, these costs stand to range in the order of thousands of dollars.

Ultimately, the potential impact of having current, accurate information for evidence-based planning overwhelmingly favours implementation of the electronic data capture system. With potential benefits to cost efficient organisational planning, and improved population health, cost savings potentially amount to hundreds of thousands of dollars.

In summary, handheld computers serve as a practical tool, facilitating the realtime collection of high quality data. The magnitude of potential cost savings attributable to improved population health outcomes overwhelming favour continued implementation.

Two additional applications involving handheld computers have been developed and are ready for implementation: an accountability tool for the Canadian Prenatal Nutrition Program, and an instrument to collect data for Prince Edward Island's Child Health Database.

Chapter 1: Introduction

Public health nursing in the Eastern Region, Nova Scotia dedicates nearly half of its annual resources toward Maternal Child Health activities[1]. For a given infant, a public health nurse spends up to two hours completing forms between the first contact with the mother during pregnancy and six weeks post-partum[2]. At approximately 1800 births per year, completing perinatal forms annually consumes up to 3600 person hours. Although critical in the assessment and care planning of mothers and infants, public health uses little of this recorded information for organisational planning. In the instances when it does, staff usually collect information through laborious, manual counting to determine coverage statistics.

The potential benefits of an Electronic Data Capture system are extensive. Depending on the design, such a system could allow routinely collected information to be utilised for long term planning. It could eliminate the need to collect or enter the same information more than once[3]. Electronic forms could validate information entered to reduce the amount of missing or incorrect data. Data entry at the point-of-care could greatly reduce errors that occur is read from written charts and entered into a computer record[4]. Coded response options could save time normally consumed by writing out information[5].

The successful integration of handheld computers with Electronic Data Capture systems would have both national and international implications. An inexpensive, electronic method to capture routine perinatal health data would overcome a large barrier in the provision of quality and timely health information. The Canadian Institute for Health Information (CIHI), a well respected data aggregation and warehousing organisation, currently does not manage a substantial public health perinatal data holding[6]. Routinely captured perinatal data in electronic form would present an opportunity for CIHI to aggregate and analyse perinatal data at a regional and national level. Such a system could also assist the Canadian Perinatal Surveillance System in its goal of establishing a comprehensive national perinatal database through the electronic transfer of data[7].

Generally in most third world countries there is "excessive and unnecessary recording and reporting of health data, with a heavy burden on service staff...often resulting in dubious quality and reliability of data." Health information systems have reduced to reporting systems for higher authorities, with little attempt to enhance ownership and build capacity to "use health information for decision-making at points of data generation."[8]

For example, in a majority of South East Asian countries the improper use of data collection tools affects the timeliness, reliability and completeness of data. Similar issues to those of the Canadian context need to be addressed in the selection and use of health information system tools and methodologies: "accuracy, flexibility, acceptability, timeliness, accessibility - availability, completeness - adequacy, conciseness, applicability - usability and cost." In the South East Asian context, Htwe

M[9], an advisor of the World Health Organisation, reports: "existing regular collected data, with all its limitations, is often adequate for decision making."

Information systems using handheld computers could address many of these issues. Researchers have already captured health survey data using handheld computers in the Gambia[10], Cape Verde[11] and Ecuador[12] (please refer to Section 2.1: Review of the literature). Implementation of routine information systems involving handheld computers faces a number of barriers, including: inadequate resources and competing priorities, inadequate technical expertise to design, implement and offer long-term support, “inadequate efforts and mechanisms to institutionalise the culture of data for decision-making”[13], stakeholder commitment and the lack of willingness to integrate different health data systems.[14]

As an alternative design to an existing information system, electronic data capture could minimise the need for post-hoc data entry personnel, potentially reducing recurrent labour costs. With data entry decentralised to the service provider or data collector, such users would need adequate training in how to code and record data to minimise the bias introduced by differences in response interpretation.

This report presents information on the piloting and application of handheld computers for the electronic data capture of routine perinatal data. It describes the findings and lessons learned from the development, implementation and evaluation of the pilot use of handheld computers to collect routine perinatal information.

Chapter two describes how the Electronic Data Capture system developed and the reasoning behind this approach. It includes a treatment of the ethical issues along with a description of the tools used to address these issues.

Chapter three offers the findings of a pre and post measurement of the users' attitudes towards computers. Emphasis is placed on how training and implementation strategies could be improved in future applications.

Included in chapter four are the findings of two separate comparisons of the data collected by the Electronic Data Capture system. The chapter describes results from comparisons of the data collected with: (1) findings of an in-house chart audit; and (2) data collected from an existing hospital-based system.

Chapter five describes the costs and potential savings of the developed Electronic Data Capture system compared with those of the existing paper-based system.

Chapter six presents the overall conclusions drawn from the pilot study. The concluding chapter also briefly describes two other applications of handheld computers and suggests future directions in the use of handheld computers.

Information technology in Eastern Region, Nova Scotia

In recent years, Public Health Services has committed itself towards integrating computers into daily activities. Both public health management and staff regard computers as a critical component in the development of short and long term planning capacity.

In the spring and fall of 1999, Public Health Services introduced electronic mail and the Web-board as communications modalities. Management challenged staff to incorporate these new technological innovations into their daily work. For the first time, public health staff sent documents by e-mail as attachments, rather than fax or courier. Management also encouraged individuals to improve their typing skills.

Based on the findings of the first LoPHID Evidence Based Planning cycle on Perinatal Care and Caring and an Information Management Case Study, Public Health Services of Eastern Regional Health Board, Nova Scotia hoped to develop a Local Info-Structure for Decision-making on the Perinatal Health Continuum[15]. As one thrust of this ambitious third LoPHID Evidence Based Planning cycle, management planned to modify the existing perinatal information structure with the introduction of an Electronic Data Capture system. Public Health Services recognised the successful introduction of such a system would be a *Proof of access,* since it would demonstrate that not only the concept was technically feasible (known as proof of concept) but it was an appropriate technology for perinatal information in the public health nursing context. Further details concerning Proof of access can be found in Annex 1: Proof of access.

1.1 Objectives

General objective: To assess the design and application of handheld computer technology to the electronic capture of routine perinatal data.

Specific objectives:

- To describe the development of a computerised information system utilising affordable handheld computers to capture routine perinatal data.

- To measure the attitudes and perceptions of public health staff towards the use of computers in daily practise.

- To assess any changes in attitudes toward computers and perceptions of perinatal information management of participants of the electronic data capture pilot study. Factors influencing these attitudes will also be considered.

- To compare the quality of data collected by the piloted Electronic Data Capture system with data collected using other systems.
- To assess the cost, ethics, acceptance by Public Health Nurses and technical challenges of the piloted Electronic Data Capture system.

- To formulate recommendations for the implementation of future local computerised information management systems.

1.2 Theoretical framework

This section explores how to conduct health technology assessments, and theories of how new health technologies or innovations become part of daily practise.

Conducting health technology assessments

According to Goodman[16], health technology assessments involve:

- explicit analytical framework;
- inclusion of all relevant domains of impact, including economic, social and ethical areas;
- emphasis on second and higher order effects, such as unintended, unanticipated, synergistic and cumulative effects;
- identification of and concern for the impact on all key parties of interest;
- consideration of effects on all relevant systems (health, education, legal, etc.);
- being carried out by multi-disciplinary groups.[17]

Goodman further distinguishes three basic assessment orientations. Technology-driven assessments determine the characteristics or impacts of one or more technologies. Problem-driven assessment focus on solutions or strategies for managing a particular problem that might use alternative or complementary technologies. Project-driven assessments focus on a local placement or use of a technology in a particular institution, program or other designated project.[18]

Fuchs and Garber[19] assert that current trends in new technology assessment focus not only on the biomedical perspective of safety and efficacy of an intervention, but also addressing broader issues such as costs, quality of life and patient satisfaction. They describe technology assessment as occurring in three stages.

First, technology assessments focus on the technical characteristics to determine if the technology or innovation can achieve a desired result in an ‘ideal' or well-controlled setting.

Second, the assessment investigates the efficacy of the technology with patients or clients under ‘average' or routine conditions through studies such as randomised control trials. This stage often employs sensitivity and specificity analysis.

The third stage focuses on the clinical, economic and social end points, including the impact on overall health outcomes, the cost of the innovation and the consequence of introducing the new innovation on patients, the treatment environment and practise.[20]

Concerning those interested in generalising health technology assessment findings to other contexts, Feeny[21] states that evidence of how well a technology works under ideal situations is likely to be highly generalisable. He states that under more-realistic everyday circumstances, technology assessment evidence is less likely to be generalisable, as with assessments of economic efficiency.[22]

Introducing new innovations into practise - theoretical approaches

The design and application of a technology into a health care institution should consider a mixture of theoretical perspectives on how behavioural change occurs. This section focuses on the behaviour change of user adoption and sustained acceptance of the electronic data capture system.

The current dynamic and varied nature of the field of knowledge transfer necessitates a clarification of the terminology used. For this section, the term 'technology uptake' refers to the adaptation, adoption and sustained acceptance of a technological innovation. 'Knowledge transfer' includes the transfer of both knowledge and practical skills to use a technological innovation.

Technology uptake is one type of behavioural change. Familiarisation with the process of behavioural change in health practitioners can help us to understand the process of technology uptake, and how to assess it. In the area of educating health practitioners, a considerable body of work explores physician behaviour change. Four main approaches - alone and in combination - appear to dominate this area: marketing approaches, diffusion of innovation theory, the social influences model and adult learning theory.

Marketing approaches

Marketing approaches originate from an advertising and persuasive communication perspective. These approaches focus on five aspects of the communication intended to increase awareness or provoke behaviour change: the communication source; channel or medium of communication; the message itself; the audience intended to receive this communication; and the setting that the communication is received.[23]

Marketing approaches often distinguish between communication intended to increase awareness and communication designed to change behaviour. In considering behavioural change alone, marketing approaches frame the process of knowledge transfer accordingly:

1. source - influences intended to change behaviour;
2. channel - often personal interaction;
3. message - local anecdote or experience;
4. audience - opinion leaders;
5.. the setting - informal environments.[24]

In the context of electronic data capture system users, one might apply a marketing approach to technology uptake in the following manner:

1. source - influences assisting the uptake of skills (that is, trainers, technical support, co-workers);

2. channel - training workshops, skill modelling through personal interaction, instruction by telephone and training manuals;

3. message - skill modelling, step-by-step instructions;

4. audience - the intended end-user of the system;

5. setting - 'work' environment, although this often varies with the task of the public health nurses' demands.

Marketing approaches reinforce the importance of the type of source, channel, message and setting in technology uptake by the intended target group. System implementers should consider these elements carefully in the design of training workshops, the provision of technical support and the development of training materials.

Such approaches however suggest information flows uni-directionally from source to audience, and do little to accommodate the dynamic nature of 'sources' (trainers, technical support, co-workers) who also adapt the technology to the end-user, and learn and adapt to the end-user's use of it. The concept of 'channel' simplistically - and perhaps inadequately - describes the complex interaction between the user and her/his influences.

Diffusion of innovation theory

Originating from sociological studies of how medical innovations actually find their way into local practice, proponents of the diffusion of innovation perspective assert several characteristics about how technological innovations spread in the medical community. First, "physicians act as communities rather than aggregates of unrelated individuals... medical behaviour is literally contagious".[25]

Second, diffusion of an innovation is a dynamic process that involves stages of modification and adaptation of the innovation to local conditions. Hindering this process of modification and adaptation may hinder the innovation's diffusion.[26]

Finally, diffusion theory emphasises the role of several key factors of the technology itself that influence how it spreads. These include:

- relative advantage of the innovation to the adoptee and patient care;
- innovation's compatibility with users norms and the local context;
- complexity;
- trial-ability - how much prospective users can use the innovation on a provisional basis; and
- observability - ease with which the innovation achieves the expected results.[27]

In the public health nursing context, diffusion of innovation theory carries relevance to the pilot project. It emphasises that adaptation of an innovation to the nursing context requires a particular process. Implementers must account for the factors influencing innovation spread.

Researchers and implementers should exercise caution in focussing primarily on the innovation. Diffusion of innovation theory does little to emphasise the experience users go through to adapt the innovation to their situation, and adapt themselves to the innovation. It does little to account for the role of participatory processes users can engage in to fit an innovation into their context, and the particular benefit of user ownership in the modification and adaptation process on both innovation diffusion and sustained use.

Social influences model

This perspective places a strong emphasis on the role of the peers' judgement and beliefs in how someone evaluates new information, or - in this context - adopts an innovation[28]. From this approach, norms of appropriateness and peer acceptance of an innovation motivate users to adopt and accept it, rather than its impact or economic merits. Proponents of the model emphasise "modelling behaviour as a member of a social group... over acquiring and applying information as an isolated individual"[29]. Greer's findings support this model among physicians, asserting that new technology uptake occurs only if local consensus exists among physicians of a given community. This follows a process of local communication regarding risk, benefit and appropriateness; the availability of local education and demonstration; and the expectations of others.[30]

The social influences model holds some relevance to technology uptake in public health nursing, although such factors may exert a greater influence at the management level of public health than with end-user public health nurses. Hence, peers may not influence whether or not a PHN uses a new innovation, but how s/he uses the innovation. For example, peer learning - the sharing of expertise of how to use an innovation between users - could also benefit technology uptake. Implementers should attempt to promote the benefits of their innovation to both the user and her/his peer group. The model may underplay the role of the imputed impact of a health technology on a user's willingness to try to adapt to an innovation.

Adult learning theory

Adult learning theory emphasises the characteristics of the expected innovation, and the user's environment. Adult learning theorists focus on the role of personal motivation, in contrast to coercion, in sustaining technology uptake.[31] Proponents value the process of educating and learning as important, since it pre-disposes a user to the innovation and reinforces technology uptake once it has occurred.[32]

In the context of introducing a technological innovation that has a tried and tested, low tech alternative (pen and paper forms), personal motivation may influence technology uptake in several ways.

A prospective user's attitudes influences how readily the individual learns: a positive attitude towards a subject matter - in this case, the innovation - can enhance learning, a negative one can dissuade it[33]. Experiences can generate positive or negative responses to a given situation and influence a person's motivation to acquire new skills[34]. Positive attitude can motivate learning and retention of information in a given situation while negative attitude may impede them.[35]

Attitude also influences the behaviour of individuals, including the sustained use of an innovation.[36]

Conclusions

Design and development

Developers should ensure that the electronic data capture system design considers for all factors that diffusion of innovation theorists propose as influences. These include the relative advantage to the user and patient care; compatibility with user norms; complexity; trial-ability and observability.

In the development of training workshops, manuals and technical support mechanisms, implementers should carefully consider the appropriate source, channel, message and setting needed to educate and transfer skills to prospective users.

The system development process must encourage personal motivation to use the system by encouraging ownership and user participation in the development and adaptation of the system to local needs. A user-driven development approach also helps to ensure the developed system meets its intended objectives while tailored to user preferences.

Educating users of how the system will benefit organisational planning and health outcomes may also motivate its sustained use. Strategies to influence the support of opinion leaders in the user group may help build peer support for the system.

Assessment

A comprehensive health technology assessment should incorporate data on electronic data capture system performance in ‘ideal' and ‘regular' settings, an evaluation of the relative economic merits of the system compared with alternative technologies and some discourse of the ethical issues involved with implementing the system.

This section offered a brief exploration of the contribution that marketing, social influences, diffusion of innovation and adult learning theorists have made to understanding the successful uptake of a technology by end-users themselves. Although all of these theories highlight a wide range of factors that govern acceptance, adoption and sustained use of a technology, a majority - if not all - of those factors influence personal motivation. Adult learning theory draws attention to personal motivation as a key factor in behavioural change and technology uptake. As an antecedent to behaviour, researchers should measure user attitude towards the technology - a key component of personal motivation - in assessing the system.

Chapter 2: Piloting electronic data capture: development and integration of the Post-partum Client Record system

2.1 Review of the literature

Application of handheld computers

A literature review of handheld computer use in short-term and routine data collection assisted the development and implementation of the electronic data capture system. The review also identified gaps where this research could make a contribution.

Short-term applications using handheld computers

Forster et al[37] collected data on malaria morbidity using both paper questionnaires and Psion Organiser II XP hand-held computers (key-pad entry) in The Gambia. Custom developed software written in OPL (similar to BASIC programming language) permitted data type and range validation[38]. Over three weeks, they found the total number of handheld collected data errors significantly lower than data collected via paper questionnaires (ANOVA $p < 0.001$). Forster et al[39] also found a statistically significant reduction in the mean time required to conduct an interview (ANOVA $p < 0.001$) and in the variability of data accuracy between different interviewers (Paired Student's t-test $p = 0.007$).

Reitmaier, Dupret and Cutting[40] used a Sharp PC1600 pocket computer (key-pad entry) to collect anthropometric data in Cape Verde. Researchers recognised that although the pocket computer could increase the speed of data collection and motivation of staff, sound staff training and careful attention to measurement details were paramount in attaining quality data.

Macintyre et al[41] compared data collected using paper questionnaires and palm-top computers during a Rapid Survey of Contraception and Fertility in Ecuador. Data collectors used the DOS-based data entry package SURVEY on Hewlett Packard 200LX palm-tops computers. Researchers discovered few differences between data collected by paper and palm-top computers. Contrary to the belief that the use of computers would disturb respondents, they noted refusal rates similar to those of paper questionnaire interviewers.

Curl and Robinson[42, 43] also compared data collected by handheld computers with data collected using paper and pencil during a two-year investigation of the qualitative processes of forensic/psychiatric nursing care in a hospital setting. Researchers compared observational data collected using the Sharp 3100 handheld computer with data transcribed from paper. Although they concluded the electronic system produced fewer errors and took less time to process for analysis, it is not clear what statistical significance tests the study employed. Researchers also did not specify whether the excess errors found in data collected by the paper method were attributable to the data collection or data entry phases.

Weber and Roberts[44] used handheld computers to collect exercise study data. The researchers used the JetForms application to develop electronic versions of their instruments. Because the application could not save data in the format of their statistical software package, an ODBC driver converted the data to dBase IV format so it could be imported by their statistical software package for analysis.

These articles reported general technical details helpful to handheld data collection system design and implementation. Several authors emphasised the importance of careful measurement practise in generating quality data - suggesting a review of nursing assessment skills and practise expectations should be completed immediately prior to this system's implementation.

Due to their short term nature, the studies provided little information of how those handheld systems might be received in a routine clinical practise setting, and what strategies or approaches implementers might take to integrating them in such a setting.

Although several studies reported lower data error rates in handheld computer data, users often participated in data collection as a full-time activity for a period of weeks immediately following an intensive training programme. It is not clear if similar error rates would be detected in a routine data collection context, where system users frequently balance data entry with patient assessment, consultation and other work.

Weber and Roberts' use of ODBC drivers should be included in the system design to ensure it is compatible with most Windows-based analytical software packages.

Routine data collection using handheld computers

A number of systems designed for more routine, day-to-day applications have had success. Most applications operated in hospital or clinical care settings where staff already felt quite comfortable with desktop applications. In many of these settings, in-house information technology support could assist users.

Karshmer and Karshmer[45] described the early stages of a pilot project that used the Apple Newton MessagePad 110 (recently discontinued, Macintosh based handheld) to assist with charting and medical diagnoses in a hospital setting. Implementers stressed documentation systems should be adopted to users, rather than users to the system. In this design, infra-red signal transmission is the main method of updating central storage data.

Le, Kohane and Weeks[46] also utilised an infrared signal transmission to aggregate data collected from a self-administered, electronic questionnaire on health-related quality of life information from outpatient breast cancer patients. Implementers preferred a wireless connection since it reduced synchronisation time and wear and tear on the device. Based on prototype trials, the authors presented a number of other design suggestions concerning handheld computers:

- when using a handheld computer as a client to a server, the server should perform all computational and memory intensive tasks;

- applications should maximise display area by displaying only essential information;

- minimise the amount of writing required; interface should only require standard gestures like tapping (ie. avoid complex stylus strokes like those needed for writing recognition programs);

- disable built-in function buttons to preclude possibility of accidentally starting up any of the built-in personal digital assistant (PDA) applications (eg. e-mail browser, MP3 player) and, possibly, deter theft;

- during data transmission, use error-detection protocols;

- use an application maintainable by non-programmers to permit easy modification of questionnaire by operator.

Several projects have focussed on developing handheld computers as facilitators of rapid access to medical information. Ebell and Barry[47] used handheld computers to store evidence-based resources (eg. Cochrane Database of Systematic Reviews, clinical prediction rules, drug information) for point-of-care access by physicians. Labkoff et al[48] downloaded medical texts and references into the Apple's Newton handheld computer to assist with clinical decision-making in the hospital setting. A future phase will link Newton handheld devices with non-local information resources via radio frequency wireless connection.

The current boom in the handheld market has led to a flurry of new developments in the handheld industry. Newer, more affordable models that have appeared on the market in recent years could prove to be more attainable for modestly funded public health authorities.

A number of publications describe the integration of handheld computers into a daily public health context[49]. Although initial attempts at home healthcare documentation used custom made handheld units developed specifically for that purpose[50], most of the current literature describes systems involving widely available handheld, palmtops and PDAs.

Wilson and Fulmer[51, 52] studied the introduction of wireless, pen-based, handheld computers to home health nursing in inner-city area of New York. Using the Fugitsu 1000 model pen-based wireless computers (7.2" x 10.7"), home health nurses are able to:

- document patient symptoms, treatments and vital signs using standardised on-screen lists;
- transmit and receive information between the wireless computer and a central database in *real time*; and

- use the computer's organiser capacities.

Nearly all issues reported by this qualitative study of nurses' initial experiences focussed on user adaptation to features related to wireless transmission and the particular type of mobile computer used. Nurses did find small screen keyboard problematic to use, but found electronic documentation to be a time saver.
Wright et al[53] also found the touch screen keyboard more difficult for users. They compared text entry using several types of handheld computers. The researchers found significant decreases in speed and accuracy when entering text via a touch-screen compared with a physical keyboard.

The benefits of implementing pen-based computer technology to home health care may not be initially apparent. Kovner, Schuchman and Mallard[54] reviewed the application of pen-based computers to the documentation of a Hospital Community-Patient Review Instrument. They found although pen-based computer records had fewer calculation errors compared with traditional written records (Chi-square $p<0.000001$), nurses using pen-based computers spent more time documenting, compared with pen and paper users (Chi-square $p<0.01$). Comfort with the system may have contributed to this increase in time: some nurses said they completed the pen and paper documentation as usual and entered data into the computer later. The researchers included a preliminary estimate of the cost of the system, but did not attempt to quantify potential savings or benefits of the system.

Noone, Cavanaugh and McKillip[55] completed a three month pilot use of Psion Series 3 Palm-top computers to collect routine home care data. As a transition step before piloting the system, implementers first adapted the home health service organisation's paper-based charting system to mirror the computerised system. Initial training of four nurses lasted for one week, each assigned a member of the support staff as her buddy in case of problems. After three months, although the nurses found computer-based charting more legible, nurses felt using the system less personal due to decreased contact with the client during data entry.

McManus[56] describes in detail a number of problems encountered by one U.K. National Health Service Community Trust's implementation of an electronic patient record system using Windows CE-based handheld computers. Users found the electronic system time-consuming and handheld computer screens difficult to read. The author highlights the importance of developing systems that respond consistently to users when errors occur, or in providing editing and exiting function controls.

Several conclusions emerged from the review of routine data collection literature. Design of a routine data collection system should take care in selecting a handheld computer with an easy to read screen. Electronic formats should minimise the use of on-screen keyboards to enter data since users of several different systems have found them difficult to use. In general studies found the mean time required for using a handheld system greater than for pen and paper systems, although authors did not clarify whether the same users had difficulties with screen visibility and keyboard use.

Infrared and wireless data transmission appear as fast, wear-and-tear free alternatives to cables for getting information from handheld to computer. Designers should consider these innovations in system development.

Designers should review and consider the user-centred, electronic format design constraints suggested of McManus and Le, Kohane, Weeks.

The reviewed literature offered little documentation of the economic impact of handheld computer systems. Only one article reviewed made reference to the cost of using handheld computer systems; it itemised only training costs and did not explore potential savings or benefits.

Little emphasis has been placed on documenting the ethical considerations and mechanisms used to protect client confidentiality. Surprisingly, very little of the reviewed literature described ethical considerations made in either the design, implementation or assessment of the handheld computer systems.

2.2 Ethical issues and management of client confidentiality

2.2.1 Ethical issues

All health information management endeavours must consider the ethical issues that arise during implementation. This report frames the process by the four basic principles espoused by Beauchamp and Childress[57] of autonomy, beneficence, non-maleficence and justice.

Autonomy

Beauchamp and Childress define autonomy as the "personal rule of the self while remaining free from both controlling interference by others and [one's own] personal limitations, such as inadequate understanding, that prevent meaningful choice."[58] Clearly, system development and implementation must view the autonomy of clients as a key ethical consideration. Public health nurses are bound by this principle to protect the confidentiality of client information collected in the clinical context. And rightly so - releasing personal information such as a woman's address to an estranged partner could inadvertently have negative consequences. Likewise, the distribution of the addresses of mothers and newborns to producers of breast milk substitutes could also result in grave consequences for breast feeding promotion.

Certainly anyone handling confidential information must avoid disclosure because it contravenes the client's right to self-governance. Some mothers disclose information with the assumption that the care provider alone uses it, and only for the provision of care. Using this information for other purposes might deter mothers from offering it.

But communities and ultimately society also possess a right to self-governance. To make good decisions, both communities - and the individuals who comprise them - need up-to-date, accurate information. Such information is important for helping individuals to give informed consent, and communities to allocate resources effectively. Access to this information is a collective right: one should consider it along with the individual's right to confidentiality.

Although one cannot condone the violation of an individual's autonomy, the impact on the individual greatly diminishes through a firm insistence of anonymity for all database records. A programmed, automated system can easily remove personal identifiers (eg. name, phone number, health card number) prior to aggregation with other data, before leaving the care environment. Together with security measures such as passwords, electronic data capture may offer greater protection of client confidentiality than paper-based systems. Unauthorised individuals could easily view a client's paper records unintentionally left at a client's home by a service provider, while password access restricts who can view client records stored on a handheld computer.

Beneficence

The principle of beneficence requires individuals to "contribute to the welfare of others."[59] Beneficence weighs in favour of implementing the Electronic Data Capture process. Chapter one describes many of the benefits of computerising a health information system. Several perinatal information management benefits arise from implementation of the Electronic Data Capture process. The automatic generation of a nursing priority screening score may reduce the time required to determine a care plan for the client. Improvements in client record legibility could liberate additional time for patient care.

The Electronic Data Capture process could promote beneficence for both the health of the individual, and communities. Health planners can analyse collected data to determine if interventions are truly effective, which ones still require development and what areas of the population need to be targeted.

Non-maleficence

One may interpret non-maleficence, or the *do no harm* principle[60], as in favour of or against implementing the Electronic Data Capture process. A proponent of the Electronic Data Capture process might suggest the information captured by the process could reveal public health interventions that are less effective and hence less beneficial to an individual compared with another intervention. Likewise, if data collected by the process could reveal care practises that negatively effect the health of mothers and infants, the use of this information in planning interventions against the care practise could promote non-maleficence.

In contrast, an opponent of the Electronic Data Capture process might argue the use of the individual's personal health information serves to violate her/his right to control how the personal health information s/he presents to a public health nurse is used.

Justice

This principle suggests to implementers the "individual not be placed in an inequitable position regarding known risk of injury that could be avoided or mitigated."[61] More than any other principle, justice promotes actions that will protect the confidentiality of client information. Maintaining the anonymity of aggregated data greatly decreases the possible unjust treatment of a woman or her infant through this process.

The principle also draws caution to the use of findings produced from analysis of captured data. Health planners must exercise rigorous analytical methods and careful consideration of the consequences of releasing a particular finding. For example, one must seriously consider the benefit from publicly releasing a finding that portrays minorities negatively in a xenophobic area.

In summary, scrutiny within the framework of Beauchamp and Childress' principles[62] highlights several important issues concerning the use of the Electronic Data Capture process. The analysis of aggregated, de-linked data from clients would likely promote the principle of autonomy if the conclusions drawn from data promote client care in the context of organisational planning. Although access to information that may contribute to the governance and betterment of society in a collective right, users of the Electronic Data Capture process must protect client anonymity to uphold the ethical soundness of the process.

2.2.2 Management of client confidentiality

The following section describes several design characteristics of the PCR system that serve to protect client confidentiality.

Features of the handheld unit

Each time the unit is turned on or someone attempts to get information after several minutes of inactivity, the handheld unit requests a password. The password protects confidential client records from viewing by unauthorised personnel. Once a unit is shut down, it is nearly impossible to gain access to the data or programs on the handheld without knowledge of the password. The unit's automatic power off feature greatly decreases the likelihood this could occur.

Should one remove the battery or divert power from the unit, the confidentiality of client data is maintained since loss of power clears both the electronic form and client data from the handheld unit.

Transferring information to a desktop computer via the process of synchronisation requires the user to enter a password on the desktop computer before synchronisation can proceed.

Features of the desktop application

MS Access 2000 engine offers an elaborate and sophisticated password system that developers can activate in the PCR system. Developers can set up a generic password for all users or specific user login names and passwords. Configuration of MS Access 2000 can establish different levels of security access for different users.

De-linking data from personal identifiers

Development of the Electronic Data Capture system placed client confidentiality as a critical concern. Before data aggregation and analysis, the system de-links identifiers from the data - personal identifiers are separated (eg. name, phone number, health card number, etc.) from what is otherwise anonymous health data (please see Annex 1: Proof of access). Since the PCR system uses Nova Scotia health care numbers as a part of the unique identifier linking different pieces of information for the same client in different databases, the system design required an additional level of sophistication beyond simply clipping off personal identifiers.

To protect the confidentiality of client health card numbers, the system scrambles the value of each digit of the database's unique identifiers before it exports the database for analysis. Each digit is scrambled differently. Annex 2 offers a model developed using Epi-Info analytical macro features and the Visual Basic programming code used in the pilot system (please see Annex 2: Programming code for scrambling numeric identifiers).

2.3 Methods

Pilot system development

System development used hardware and software that met the needs of public health nurse work habits, and had features expected of an electronic data capture system. A description of the motivation for using this hardware and software lies in Annex 3: Hardware and software selection.

Development of the desktop component of the pilot system, known as "Post-partum Client Record System", occurred in Microsoft Access 2000 Visual Basic for Applications. The Post-partum Client Record System can collect and manage client data independent of the handheld computer. System development included this feature to offer a tool for perinatal client information management in the event that public health discontinue the use of handheld computers.

Application development occurred in coordination with database content development. During the initial design stages, the developer recognised that the content of existing perinatal forms required adaptation for input into a computer and subsequent analysis. Guided by documents outlining organisational targets and standards for perinatal care, existing forms and other assessment instruments, a committee of public health nurses, a nutritionist, a dental hygienist content and nurse manager developed database content.

Once the committee clarified database and form specifications, the developer used Syware Visual CE 4.01 (Professional Edition) to develop handheld versions of desktop forms applications in the late stages.

During development of handheld and desktop applications of the pilot system, the developer consulted software development texts, on-line software tutorials, web sites and telephone technical support personnel of Microsoft Corporation and Syware Corporation (please see Annex 4: Postpartum Client Record System User's Manual, Appendix III).

Over a three month period, user feed back and suggestions led to the development of subsequent versions of the piloted system, each taking into account the problems of the previous version.

Training for the pilot system

Participants of the pilot study had 11 hours of training. Conducted by the nurse manager and pilot system developer, participants received training on how to use both the desktop and handheld versions of the pilot system. To encourage successful implementation of the pilot system, participants also reviewed public health nursing practise expectations and the motivation and benefits of the electronic data capture system.

Pilot system implementation

Each week, nurses reported the number of clients entered into the system and any difficulties they encountered. The Nurse Manager, Ms Agatha Hopkins, initially received reports, and passed on any technical concerns to the developer. Throughout the piloting period, the implementation process encouraged nurses to call a telephone technical support hotline if they encountered any problems. Either the nurse manager or developer visited participating offices every couple of weeks to see how nurses progressed.

2.4 Results

The “Postpartum Client Record system”, the pilot Electronic Data Capture system developed for this pilot study, assisted in the capture of early postpartum data. Annex 4: Postpartum Client Record System User’s Manual contains a user manual for the Postpartum Client Record system including a training guide for public health nurses.

Users identified a number of issues through informal individual and group discussions as well as comments included on the post-test questionnaire of nursing attitudes towards computers. These issues included:

- handheld computer screen difficult to read in poor light conditions, despite backlighting illumination features;
- handheld computer quite slow at displaying previous/next page of electronic forms;

- some PHNs, who did not use the system for weeks at a time, needed to be re-familiarised with the system;
- at least one PHNs chose to jot notes on paper during a home visit and complete the electronic forms at a later time;
- some nurses perceived the process of completing an electronic client record as time consuming.

Table 1 summarises user comments on the pilot system. Although the developer resolved a large number of technical problems encountered during piloting with newer versions of the system, Annex 5 describes some technical issues observed throughout the pilot study (please refer to Annex 5: Technical problems and issues).

2.5 Discussion

Tested with mock clients (ideal setting), the system could successfully capture client record information remotely using handheld computers, transfer the information to the desktop computer for storage, printing, exporting (with client identification removed) and analysis. Achievement of the desired result in an 'ideal' setting constitutes a successful first stage assessment, as described by Fuchs and Garber[63]. The following section contributes to the second stage of technological assessment - the efficacy of the technology with clients under average conditions, addressing aspects of the technology itself and its implementation.

Handheld computer hardware

According to its manufacturer, the Aero 1530's display balances the use of ambient light to reflect an image with the use of backlighting. Most public health nurses found the screen easy to read in well-lit environments (for example, outdoors or in offices) and found backlighting illumination effective for completely dark environments. Some nurses found backlighting illumination difficult to read in dimly lit environments encountered in clients' homes. McManus[64] also noted screen visibility problems with handheld computers used in their study, suggesting further study is needed to identify (or develop) a suitable screen for home care users.

Users found the handheld computer quite slow at displaying the previous/next page of electronic forms, particularly longer formats like the mother and infant sections of the Public Health Assessment. Although not raised as an issue in literature reviewed, hardware or software limitations could both contribute to the slow performance of a lengthy electronic format.

Due to the declining birth rate during the pilot study, several public health nurses found they did not use the handheld units for extended periods. Storage for several weeks without regular battery charging completely voided both the main rechargeable and backup batteries. The subsequent handheld computer memory loss required users to restore the Visual CE forms to the unit before entry of its next use. In addition to the time costs involved with restoring the unit's former settings (one hour) the non-rechargeable backup battery required replacing each time this occurred.

To protect handheld unit screens from fingerprints and scratching, designers cut overhead projector acetate sheets to fit over handheld screens. Do-it-yourself screen covers serve as an effective and inexpensive alternative to commercially available handheld screen protectors ($2.00 USD per sheet).

Authors of several articles[65,66,67] describe the use of infrared and wireless data transmission. Although this system's handheld computers included a built-in infrared port and expansion slots for wireless modem cards, office desktop computers did not possess these features. The prohibitive cost of adding such features and gaps in the local wireless transmission service precluded infrared or wireless data transmission during piloting.

Handheld computer software

Pilot system development incorporated many of the design recommendations of Le, Kohane and Weeks[68]. The developer programmed desktop applications to handle most computational and memory intensive tasks, such as de-linking of data from personal identifiers and exporting to Epi-Info 6 file format. This permitted the dedication of limited handheld computer memory resources to capturing data. Electronic handheld questionnaires maximised available screen display area through the use of controls like pull-down response options. Changing environmental settings permitted built-in function buttons to call up key forms, rather than the built-in personal digital assistant applications.

Contrary to Le, Kohane and Weeks[69], the developer did not incorporate error detection mechanisms in the applications themselves, and relied instead on those of the Windows CE Operating System. As well, although non-programmers can readily develop new handheld forms in Visual CE, it is not easy to add or delete data entry fields for a form already made. Any changes in handheld databases would also require changes in the desktop application.

As per the recommendations of McManus[70], through standard form design and use of navigation controls, the developer attempted to create a consistent form environment to navigate through. Due to time constraints, the developer did not sufficiently pilot the system to create a consistent and thorough help file, or complete reference manual to assist users. Piloting relied heavily on telephone technical support and informal user support networks that developed among the nurses.

As mentioned, software limitations may have contributed to user's dissatisfaction with the speed of electronic forms. The software required that an entire assessment format start up on the handheld before a user could begin entering data, and users needed to wait a greater amount of time for longer assessment formats to load. The Visual CE software platform used to build handheld forms is itself a program; electronic forms developed to run directly in Windows CE could potentially run faster, although their development would require a proficiency in computer programming. Forms containing many variables with long lists of answer responses also tend to occupy more memory, and require a greater amount of time to load.

The original design of the PCR system permitted access to all client information from a single form - the infant menu form. Organised in this way, users could navigate to information stored on ten different databases (since each assessment form had a separate database) from a single point. Although initial system designs allowed users to jump to client information on any of the assessment formats from this form on both the desktop and handheld computers (please see Annex 4, Table 1: List of PCR1.0 database names), the developer found it difficult to use such jumps to access other form features on the handheld software. Upon tapping the jump button, the desired assessment format would open, but would not display data for the desired client record.

Compared with Epi-Info's data entry options, the handheld software offered a limited ability to jump to different parts of the format. Although the developer could set up jump buttons to move the user, Visual CE 4.01 handheld software did not facilitate data entry-dependent jumps that move users to different parts of the form depending on the response selected.

Visual CE does not allow the developer to restrict the range of responses for numeric variable controls. For example, the developer could not limit maternal age responses to between 14 and 55 years. Other software application controls allow entry of both open and pre-coded responses. For example, at a single control in Epi-Info one can both restrict entry of maternal age datum to a range of 14-55 and also allow a pre-coded response of ‘99' for missing data. Visual CE did not permit such hybrid controls: controls could only accept either exclusively pre-coded responses or exclusively open responses.

The Visual CE software platform only permits such text box controls - those requiring the use of an on-screen keyboard - as must-be-completed. Although requiring the completion of a field would help to reduce the amount of missing data, pilot system users encountered some difficulty entering text on the handheld computers via on-screen keyboards during the early stages of testing. This is similar to the experience of handheld users’ described by Wright et al[71] and Wilson and Fulmer[72]. In later versions of the pilot system, the developer chose to control the majority of data entry using drop-down and radio button list controls to reduce inter- and intra-user data entry variability, and maximise use of screen space.

Visual CE allows storage of response options for drop-down lists in either in the form’s file or in external databases. Response options stored in the format file load and display quickly but are difficult to edit. Because the pilot system introduced several “open ended” questions, the developer favoured external database storage for several controls. Response options stored in external databases are easy to edit but increase the time required to load and display a form; synchronisation also becomes slower since response options on the handheld must reflect those on the desktop computer. Visual CE also alphabetised option lists stored in external databases resulting in a difference in the ordering of response options on the handheld and desktop versions. Users familiar with the order of responses on the desktop version found this confusing.

As suggested by Weber and Roberts[73], the developer used a handheld software platform that employed ODBC drivers to ensure data collected by the handheld computer was compatible with most Windows-based analytical software packages.

Although Microsoft Activesync established and maintained a connection between the desktop and handheld computer, Visual CE's VICESYNC.EXE program actually synchronised the pilot system databases. The number of databases, variable fields and records transferred during the synchronisation process affect its duration. The process can occur quite slowly, requiring more than one minute to transfer a single client record.

With an extensive collection of forms and associated databases to download to the handheld unit, manually installing the handheld software and forms for the PCR system is time consuming and complicated. The developer found it easier to use the backup/restore features of Windows CE. Once the developer uploaded all necessary software and forms and configured all Windows CE environment settings (for example, establishing the appropriate communication port speed) onto a handheld computer, they made a backup copy of this handheld's entire memory contents. Loading software, forms and environment settings onto the other handheld computers required the developer to simply ‘restore’ the backup copy onto the rest other handheld units. Windows CE erases all information contained on the destination handheld prior to the ‘restoration' in favour of the ‘restored’ data.

Due to differences in the processor designs of different handheld computer models, using Windows CE's backup/restore function to upload information will only work on handheld computers of the same model as the handheld from which the backup originated. For example, a HP Journada 420 cannot use backup files from a Compaq Aero 1530 to transfer information.

Desktop software

The replacement of paper forms with electronic ones required data to flow bi-directionally between desktop and handheld computers. Data transferred from handheld-to-desktop needed to remain in a data format that was both viewable on the desktop computer and transferable back to the handheld computer with negligible alteration.

The developer had little success in getting data to flow from the desktop computer back to the handheld unit using Epi-Info 6. Public health managers expected the desktop software would allow viewing of data transferred from handheld computers on a record by record basis. During attempts to use Epi-Info 6 for bi-directional information flow, the developer successfully wrote automated macros to transfer (into dBase format) and import data from the handheld computer into Epi-Info 6 record (.rec) format.

The developer did not succeed in getting that same information from Epi-Info 6 format to the handheld computer. Epi-Info 6 uses its ENTER program module for the entry, review and editing of data on a record by record basis. To ensure the proper format is used for viewing data, Epi-Info 6 codes questions from the questionnaire (.qes) file into the record (.rec) file. This alteration renders the datafile corrupted for exporting into dBase format - preventing Visual CE from loading the data back into the handheld computer.

Epi-Info 6's ANALYSIS program module can view handheld form data on the desktop without altering the datafile. Users can view data in an aggregate form in the analysis program and make changes using the UPDATE command. Epi-Info 6 can also successfully export this data back into dBase format for viewing on the handheld computer. However, users find this approach quite complicated and tedious since responses in most data fields are coded so that numbers representing an entry are displayed; understanding data often requires the use of a coding sheet.

In addition, Epi-Info 6 restricts the length of records to 2048 bytes; it cannot read databases of any greater length in analysis. Concern for exceeding this size restriction arose not from the storage of pre-coded response fields but from contact information such as name and address.

The developer also encountered several data type problems in converting from dBase to Epi-Info record format. Epi-Info 6 cannot automatically restrict the length of text fields and so each text field consumes 255 bytes. It also cannot control the number of decimal places of both integer and real number data types, resulting in five decimal place responses; for example, "1" appears as "1.00000".

The developer selected MS Access 2000 as the desktop application primarily because it permitted bi-directional information flow. Since Visual CE can write handheld data directly into the file format used by the desktop application, automated macros can easily transfer information back to the handheld. File transfer via MS Access 2000' s ODBC driver avoids field data type and file size problems associated with Epi-Info 6.

A sophisticated data management application, MS Access 2000's pre-programmed macros (known as "Wizards") can generate forms, databases, queries and even other macros. Using these wizards, the developer completed the majority of work needed to make desktop databases and forms for viewing handheld data, although some types of data entry controls (for example, check file (.chk) style control of response-dependent, conditional jumps) require programming in Visual Basic for Applications code.

The analytical features of MS Access 2000 are quite basic. The developer programmed features in the desktop application to export non-nominal data into .dbf format and import the data into Epi-Info 6 for analysis.

MS Access 2000 also possesses features interoperable with other Microsoft applications. Future development can use MS Access 2000's features to allow users to send anonymous data via e-mail, and integrate time management tools such as electronic daily schedule planners into both the handheld and desktop applications.

Key drawbacks to the use of MS Access 2000 as the desktop application include cost ($199 CDN for a single user license) and desktop system requirements, such as a fast processor, adequate memory and a considerable amount of hard disk space. This may limit its application in organisations that do not meet hardware requirements and is in stark contrast to Epi-Info 6 ($20 for a registered copy).

The participating public health organisation possesses limited technical know-how to support modifications to the current MS Access 2000 based system. Adding new content to electronic forms may require contracting external expertise to make changes, depending on the level of complexity. In contrast, several members of the Public Health Services staff have received extensive training in Epi-Info 6.

At the time of development, the EPI 2000 software package was still at beta stage testing. In contrast to the record (.rec) format of its DOS-based cousin, EPI 2000 stores data primarily in the MS Access 97 format. Bi-directional data flow should occur with little difficulty since the appropriate ODBC driver needed to convert handheld data to this format is publicly available from the Microsoft website. EPI 2000 may offer a cost saving alternative to MS Access 2000; developers should explore it in future attempts to create a system with bi-directional information flow.

Pilot system implementation

Considered from the perspective of Diffusion of Innovation theorists[74] (please refer to Section 1.2), pilot system design and implementation did influence technology uptake on some levels. Training sessions at the beginning of the training programme reviewed the motivation and benefits of the electronic data capture system to convey the relative advantage of using the system. An iterative, user-driven, participatory design and implementation process helped to build user ownership of the system, ensure the pilot system's compatibility with user norms and local environment, and confirm user satisfaction with the system's level of complexity.

System design and implementation could have further promoted technology uptake on other levels. More opportunity for trial-ability would probably have benefited the training and implementation process. With the demands of other work commitments, pilot users had little opportunity for provisional use of the pilot system during the two weeks between training sessions and formal implementation. Glitches in the electronic data capture system during initial weeks of implementation further challenged entry of client information into the system (observability).

During the pilot study system developers - rather than public health nurses - delivered training information and provided formal, telephone technical support. Due to limited time available to develop and pre-test the pilot system, the training sessions could not utilise proficient users - such as those involved with initial testing of future systems - to train their peers. Compared with outside trainers, proficient public health nurse trainers could better customise training messages with their personal understanding of user perspective and how the new technology fits into the nursing work context. Their day-to-day presence would make available full-time, peer-based technical support in the workplace setting. These public health nurse trainers would also remain in-house long after the dismantling of pilot study support mechanisms.

Although researchers generally found different aspects of Diffusion of Innovation Theory, Marketing Approaches, Social Influences Model and Adult Learning Theory offered useful insight into the integration of the pilot system into practise, the theories placed little emphasis on the dynamic nature of new technology implementation for all parties involved. Experience from this study suggests a dynamic, responsive process of adaptation occurs not only with pilot system users but also with trainers, technical support personnel, and - possibly to a lesser extent - with public health management and clients exposed to the new technology. This collective, on-going adaptation process also contributes to the integration of the new technology, and future implementers should consider its implications on how trainers and technical support personnel respond to user issues throughout the pilot study.

Reitmaier, Dupret and Cutting[75] noted the importance of investing careful attention to measurement detail. As such, implementers allotted a half day session to reviewing nursing assessment skills and practise expectations prior to the system's implementation. The nurse manager clarified how nurses should assess and record their response for each question on the electronic forms.

A number of users found pilot system forms longer in the length and more time-consuming to complete than the original paper forms. Surprisingly, the median time to complete the electronic forms was slightly less than the time required to complete the original paper forms (55 minutes vs. 53 minutes). This finding also contrasts those of Kovner, Schuchman and Mallard[76], although differences in format design and content between their system and this pilot system might easily account for the difference in findings. Part of the difficulty users faced may arise from the greater amount of client detail required to complete the electronic version. The developer may have achieved a more successful transition to electronic forms if all nurses used revised paper forms that mirrored the electronic versions before the pilot study as Noone, Cavanaugh and McKillip[77] did.

Kovner, Schuchman and Mallard[78] also observed a process of recording data twice - first in notes or on old forms in the home to be later transcribed onto the handheld. A lack of comfort with the system may have made completing an electronic form difficult to manage without compromising client-nurse interaction. User comments requesting more training and opportunities to practise using the pilot system (please see Table 1) support this inference. Users less confident with the system may require a more integrated training program involving technical support “buddies” who travel to the home with the user as described by Noone, Cavanaugh and McKillip[79]. A longer implementation period may allow users to become more comfortable with using the pilot system.

The low birth rate effectively extended the pilot study’s time to three months, twice the time originally anticipated to collect 100 cases. Nurses completed fewer client records per week (some entered fewer than one client record per week), reducing their use of the pilot system and challenging their ability to become proficient at using the system (for user comments, please refer to Table 1).

Infrequent use may also have contributed to the greater dependence on telephone technical support during the pilot’s second month. Some informal mentor relationships did develop between nurses more comfortable with the system in the Sydney office, allowing nurse-to-nurse support in that office.

Following the three month pilot study period, public health nurses continued to use the pilot system for an additional three months. Although the developer offered telephone technical support during the months following the pilot study, he did not receive any requests for assistance. The continued electronic capture of data during those final months suggest either a greater overall comfort with the system and better established support network, compared with the pilot period.

2.6 Conclusions and recommendations

Designers successfully developed an electronic data capture system that permits the remote capture of client information on electronic forms, and transfers the information to office desktop computers for storage, printing, exportation in an anonymous form and analysis. Practical implementation of the system in a pilot setting revealed a series of recommendations that can enhance its efficacy under 'routine' conditions.

Aspects of various behaviour change theories - including Diffusion of Innovation, marketing approaches, Social influences model and Adult Learning Theory offer valuable insight towards the sustainable integration of a new technology. They highlight the need for improvements in trial-ability and observability, peer-to-peer training and support mechanisms and increased user ownership of the pilot system. These behaviour change theories do not emphasise the dynamic, responsive process of adaptation that also involves trainers, technical support and user management.

Successful development and implementation of an electronic data capture system requires the developer have a clear understanding of all stakeholder expectations for the system. Frequent, on-going dialogue with pilot users should complement rapid, technical response of two forms: (1) interactive technical support - if a developer can guide the user to resolving their own problem, and (2) the development and integration of revised versions of the system. The developer found frequent user feedback essential for proper system development, although lessons learned from existing literature assisted with early system development.

With users previously familiar with only paper-based data capture systems, improvements in two broad areas - technology and skills transfer - could serve to benefit future development and implementation of electronic data capture systems. Further hardware and software development will improve data capture functionality and possibly user acceptance. Better training and support mechanisms could improve system integration. Based on the issues identified in the discussion section, the section following proposes a series of recommendations intended to improve technology and skills transfer.

Recommendations

Handheld computer hardware

Based on the pilot study experience of users and the developer, the following recommendations are suggested concerning handheld hardware:

- To improve visibility in dimly lit environments, handheld screens should be more transmissive and less reflective than the Compaq Aero 1530's display design.
- To improve the speed electronic formats are displayed, use a handheld with a faster (>70MHz) processing speed than the Compaq Aero 1530.
- To reduce costs associated with replacing backup batteries and lost forms, periodically remind staff of the importance of keeping handheld units regularly charged. A different staff member could be designated each week to make sure

each unit is charged.

- Overlay handheld screens with clear plastic sheets to protect screens from fingerprints and scratching. Overhead acetate sheets cut to screen size offered an alternative to costly commercial products.

Handheld computer software

Based on the pilot study experience of users and the developer, the following suggestions are offered concerning handheld software:

- To improve the speed electronic formats are displayed, several strategies might be considered: use smaller electronic formats; develop forms at a lower programming level (for example, develop in Visual Basic instead of Syware Visual CE) and reduce the number of variables requiring long lists of responses.

- To simplify the system of accessing specific client records on the handheld, the ‘jump to another form' feature of the Syware Visual CE software requires further exploration and integration into current forms.
- Inform software developers of how to improve the sophistication of data entry controls to allow greater control over how data is entered. Encourage the development of controls that permit data entry-dependent jumps. Encourage developers to design more types of controls that can be designated as must be completed.
- Avoid using data entry controls that require use of the on-screen keyboard, as

users find on-screen keyboard entry difficult.

- Where possible, store response options for drop-down list controls in the format file itself, rather than in external databases. This will reduce the confusion associated with alphabetised responses (see Discussion section for more details) and may improve form display and synchronisation speeds.
- Data conversion to most Windows-based statistical analysis software simplified with use of handheld software platform that uses ODBC drivers to import and export data.
- Use the backup/restore function of Windows CE to reduce time transferring forms onto handheld computers (for details, refer to Section 2.5: Discussion).

- The time required for synchronisation can be decreased with several strategies: minimise the number of fields and records being transferred; increase the communications port baud rate and use an Ethernet card for high speed data transfers.

Desktop software

Situations where one expects to transfer data from handheld to desktop only may be handled successfully using Epi-Info 6, although limitations in record length and data types must be considered.

Situations where data is to be transferred bi-directionally between handheld and desktop should employ a more sophisticated database management application like

Microsoft Access 2000. Developers, however, should be aware of the greater cost, size and technical knowledge required to use Microsoft Access 2000 compared with Epi-Info 6. In the future, Epi 2000 should be explored as an inexpensive alternative.

Pilot system implementation

Based on the experience of users and the developer during the implementation period, the following recommendations are suggested:

- Review and reinforce service worker assessment and practise expectations to encourage a consistent level of data quality among data collectors.
- As a transition measure to help users to become familiar with the new electronic forms, replace existing paper forms with new forms similar to the electronic forms several weeks before transition to electronic forms.
- Allow for a longer implementation period to permit users to become more familiar with the pilot system (e.g. 6-12 months).
- Develop a *mock client* that nurses can enter into the system if they have not had the opportunity to complete one during a given week. This is intended as supplementary training to maintain the nurse's skill level and familiarity with the system during the initial weeks of piloting.
- Develop a formal mentor system (at least one in each office), using the mentors of the training session. If necessary, mentors or technical support 'buddies' can initially accompany less confident users on actual client home visits to assist them if problems should arise. Bulletins describing solutions to problems

frequently encountered by telephone technical support could be passed to mentors so they can assist colleagues *on-site*.

Chapter 3: Changes in attitude towards using computers after using the Post-partum Client Record system

3.1 Background

A growing body of literature has examined the process of introducing a computer information system to nurses in a clinical hospital setting[80 81 82 83]. In particular, articles have focussed on the learning process nurses must go through to acquire new computer skills. Nursing staff often find the integration of computers to be a stressful experience. Considerable learning must take place in the context of the time constraints of daily tasks[84]. Positive attitudes towards computerisation may enhance the learning process[85]. Some researchers believe computer systems cannot reach their full potential unless the attitudes of nurses toward acceptance and utilisation of computers are understood[86].

Although several articles describe the introduction of a computer information system in public health, fewer actual focussed on the learning process nurses underwent[87 88]. For more details, please refer to Section 2.1 Review of the literature.

In the case, both Public Health Services' staff and management expressed a need for the computerisation of health information. Recent months saw the introduction of new computerised information technology (eg. word processing, e-mail and ‘web-board' systems) into daily work activities. Although Public Health Services’ management had introduced these computerised information technologies in the Fall of 1999, staff continued in the process of becoming proficient in these technologies throughout the pilot study in the Spring of 2000.

This chapter describes the study “Public health nursing: attitudes towards computers and perception of perinatal information management in daily practise”. As a component of the electronic data capture pilot study, the study intended to identify the impact of the electronic data capture process on attitudes towards computers and perceptions of perinatal information management of nurses who participated in the pilot study. Researchers paid particular attention to changes in those attitudes/perceptions and the factors that may have influence them.

3.2 Review of the literature

The framework found in Section 1.2 explores the theoretical background for the assessment of this pilot study. It recognises the importance of a well-designed implementation process and positive user attitudes in the successful uptake of a technology into daily practise. This section reviews the existing literature in these two areas.

Attitude towards computers - past studies

Several articles featured the measurement of work activity changes and nursing attitudes toward computers. Staggers[89] found although many researchers have emphatically described the *potential* benefits of computerisation, few studies have empirically demonstrated this. She suggests a quasi-experimental approach to looking at nursing attitudes before and after computerisation: compare users with non-users. Staggers also criticised past studies for not taking into account the interaction of other potential factors of influence, such as education level, computer exposure, computer knowledge and job description.

Brodt and Stronge[90, 91] developed and administered a 35-item Likert (summative) scale to measure nursing attitudes towards computerisation. Among 225 nurses (82% response rate) at a mid-western community hospital, they used one-way ANOVA techniques and found significant (ANOVA, $p < 0.05$) differences in attitude towards computerisation related to education, length of service in the nursing profession and type of nursing unit. Researchers found more favourable attitudes held by: RNs, when compared with LPNs; nurses with greater than 21 years nursing experience, compared with those with fewer than 10 years; and Rehab-Peds nurses, compared with nurses from other units.

Several other research groups used the same questionnaire. Simpson and Kenrick[92] studied nurses in a British hospital. Among the 208 (48%) respondents, researchers found negative attitude towards computers correlated with the nurses' age and number of years of work experience. Citing their own findings as well as others, researchers suggested both appropriate clinical information systems and nurses' understanding of the benefits of computerisation need further development.

Scarpa, Smeltzer and Jasion[93] also used the Brodt and Stronge instrument. They found that only previous experience with computers correlated with more favourable attitudes towards computers, compared with no previous computer experience. The study's low return rate (40% response rate) may have contributed to the difference between their findings and other Brodt and Stronge questionnaire studies.

One research group measured pre-test and post-test nursing attitudes during the integration of a computerised clinical information system using a tested, 12-item Likert scale. Murphy, Maynard and Morgan[94] found despite positive attitudes prior to integration, attitudes became less positive after a three year period of training and integrating a patient care information system. In this particular group, the most common comment criticised use of the computer system resulting in "too much time away from patient care". Researchers did not find any demographic characteristics related to computer attitudes in the 224 nurses surveyed. The authors did not account for the responses of a control group.

Several conclusions emerge. Researchers who cited the use of Brodt and Stronge's instrument[95 96 97] utilised Analysis of Variance techniques to compare the variability of responses in different groups, rather that the effect of a factor on different individual's attitude towards computers - the approach taken in this study. Despite this difference, these articles highlight characteristics that further research should explore.

Extensive piloting and use of Brodt and Stronge's 35-item instrument in several studies suggested that nurses understood the instrument well, and researchers should consider it in instrument design. The 12 item scale developed by Murphy, Maynard and Morgan[98] focussed heavily on a proposed, proprietary hospital computer system; its content appeared less relevant to this study's instrument design.

Integrating computer information systems

As the process of integrating computer information systems can play an important role in the attitudes of novice computer users, a brief review of integrating information technology in the health care setting follows.

Extensive description exists on the integration of information technology into the health care setting. A number of articles have explored the process of computerisation in nursing.

Individuals involved with health information management have emphasised the importance of a user centred approach: designing electronic documentation that requires modifications to be made by the system rather than the user[99]. McAlindon, Danz and Theodoroff stressed the importance of involving nurses in the process of computerisation from its onset[100].

Adaskin et al[101] interviewed staff nurses, nurse educators and administrators facilitating the integration of computers to determine what factors assisted nurses in the computerisation process. Researchers identified six important factors in preparing nurses for computerisation: strong leadership, effective communication, organised training sessions, established time frames, carefully planned change and choice of software. The authors offered a number of suggestions:

- *training* - conduct training in several short sessions rather than one long session; if possible, avoid mixing fast and slow learners together in the same training groups;
- *change process* - provide positive rationale for changes occurring; provide

workshops and other preparation to increase knowledge of computers;

- *planning* - all paper formats should be designed and pretested; nurses should become familiar with the system before implementation; nurses should also be involved in selecting a system and software;

- *implementation* - system should be ready to function without undue down time - avoid negatively effecting workflow; a 24 hour help desk is invaluable; extra-staffing to cover training and planning period;

- *communications* - information should not monopolise staff meetings;

- *system design* - minimise number of screens and steps required to input information;

- *leadership* - provide extra staffing; visible, on-going administrative support.

Nagelkerk, Ritola and Vandort[102] elaborated on how their institution applied the findings of Adaskin et al to their institution. They presented several strategies used to improve the process of computerisation. To improve access to technical support, they placed schedules on each unit identifying times a resource person would be available and listed telephone numbers for questions requiring immediate attention. In keeping with Lewin's Field Theory[103 104], implementers encouraged acceptance and use of their computer information system by helping nurses to understand the need to implement the new system. A team leader or representative communicated new IT information to the team, and/or issues or concerns to management during the implementation process. Implementers also developed a detailed time line.

Ash[105] interviewed administrators, faculty, computer professionals and library staff who had been involved in integrating information systems at three academic health science centres. When asked for success factors in implementing information technology innovations or systems, respondents' comments focussed around six factors: mandatory usage of the system; ease of use of the system; understanding of the rewards of using the innovation/system; good planning; good support to those using the innovation/system; and having "champions or respected colleagues" who can lead and promote the effort of adapting to the new innovation/system.

These computer information system integration articles suggest several important conclusions. Computer information system implementers should include mechanisms that inform users of the rationale for the computer system's introduction, and the benefit to users. Prospective users must participate in the design of the information system. Where possible, developers should adapt information system design to user needs. Successful information system integration offers users adequate access to training and technical support. Implementers must carefully plan the system's introduction into the work environment, and include some mechanism for communication of information between management and users.

3.3 Methods

Instrument development

The researcher took a standards-based approach to instrument development. Following an extensive literature search on the measurement of nursing attitudes towards computers, the instrument design process considered several existing instruments[106] [107] [108]. Nurses in Ontario and Northern Nova Scotia pilot tested the instrument to confirm that questions were appropriately phrased, and statements clear and comprehendible. Managers at Public Health Services reviewed the final version of instruments before their submission to a regional ethics committee for approval.

Survey methodology

To account for the effect of other computer-related innovations introduced into the public health workplace (see Section 3.1 Background), the researcher conducted a 'pre- and post-' measurement of attitudes and practises among both public health nurses participating in the pilot study and non-participants. The researcher measured the attitude and perception of both pilot study and non-study participants with the intention of discerning changes associated with the electronic data capture process from change that may have resulted from the impact of other information technologies. Annex 6 offers a copy of the survey instruments used.

To determine a change in the attitudes and perception of service providers, researchers linked pretest and post-test responses via a unique identifier administered by a third party. The process occurred as follows:

- A third party participant - someone other than the researcher or respondents - distributed service providers questionnaires and assisted in the follow up for their completion and return. S/he labelled blank questionnaires with an unique identification code only known to her/him and inserted them into envelopes addressed to specific service providers. The envelopes also included a pre-addressed envelope (affixed only with our address and no identifying marks) to return the completed questionnaire in.

- The third party participant distributed questionnaire envelopes to public health nurses for completion. A letter preceding the questionnaire instructed nurses to return their responses in the envelope provided by mail.

- Upon receipt of the completed questionnaire, the researcher informed the third party participant of which identification codes he had received. This allowed the third party participant to follow up on the return of any remaining questionnaires.

- The third party participant distributed questionnaires immediately prior to when pilot-study participants began training and immediately following the completion of the pilot study with the Post-test Section of the questionnaire.

This process design protected the anonymity of participants. No individual had access to both an individual's code and the list of unique identifiers. No individual could link questionnaire responses to a service provider's identity while late responses could still be followed up. Following analysis, researchers only presented aggregate data in any reports or publications.

Analysis

A majority of questions assessing current attitude towards computers and perinatal information management asked respondents to rate statements on a five point rating scale where 1= "strongly disagreed", 2="somewhat disagreed", 3= "neither disagreed nor agreed", 4= "somewhat agreed" and 5= "strongly agreed".

Researchers dichotomised responses to permit binomial cross-tabulation of factors. Dichotomisation took careful consideration of the meaning of all responses given for a question or statement. When the researcher could not group responses by semantics and test aggregations suggested no clear aggregation point (observed for several continuous variables), the analysis dichotomised responses at the median since the sample had too few respondents to conduct a sufficient analysis. For information about the dichotomisation of specific variables, please refer to Annex 7: Computers in public health nursing - analysis macros used to generate binomials.

Analysis also generated contrasts based on responses for each statement among pilot and non-pilot study participants and pre-pilot and post-pilot study period participants. The sections following detail notable findings.

The researcher employed the Wilcoxon Signed Rank Test to assess the significance of differences between the median response before and after the pilot study period of participants. For all significance tests used, researchers used the customary 95% confidence level to delineate significant findings from chance ones.

Fisher's Exact test delineated chance findings from significant differences between groups. Qualitative data from questionnaires, information revealed from personal interaction with pilot study participants and responses from an informal group discussion enriched analysis by offering possible explanations for these differences. Where stated, Odds Ratios and confidence limits describe crude estimates only and do not account for the effects of other factors.

3.4 Results

Information base on Attitude towards Computers and Perinatal Information Management in the Eastern Region of Nova Scotia

Of 38 public health nurses in the Eastern Region, 27 public health nurses (PHNs) completed the pre-test questionnaire and 26 PHNs completed the post-test. Some 24 PHNs completed *both* questionnaires, including all pilot study participants (12/12) and an equal number of non-pilot study participants.

The age of PHNs who completed the questionnaire distributed evenly between the range of 27 to 59 years ($\bar{x}$ = 43, n=23). A negligible difference in average age existed between pilot and non-pilot study period participants (44 vs. 43). Four respondents did not specify an age.

On average, respondents have worked an average of 12 years as public health nurses (Range 1-28, n=27).

Concerning the respondent's highest level of formal education, most respondents completed RN-Baccalaureate level qualifications (16/24). Six respondents possessed RN-Diplomas while two completed LPN level training. One respondent completed RN-Masters level education. Three respondents did not specify.

A contrast of the respondent's age (dichotomised at the median) by her educational qualifications revealed that all younger nurses (7/7) had RN-Baccalaureate or RN-Masters level qualifications while only 6/13 older nurses possessed the same level of qualifications. Analysis does not easily attribute this difference to chance (Fisher's Exact test p-value = 0.044). It is possible more younger respondents have RN-Baccalaureate or Masters level education compared with older respondents due to changes in nursing education programs, professional nursing qualifications over the years and growing societal recognition of the equity of women.

The questionnaire asked respondents when they received their most recent degree. Responses ranged between two and twenty-seven years from the date of questionnaire completion ($\bar{x}$=15 years ago, n=19). Seven respondents did not specify. On average, pilot study period participants (6/7, $\bar{x}$=1989) received their degrees more recently compared with non-study participants (2/9, $\bar{x}$=1983)(Fisher's Exact test p-value=0.04; Analysis dichotomised responses for the year most recent degree received at the median). Although it is not clear why this difference exists, geography may play a role as all pilot study participants live and work in the Sydney / Industrial Cape Breton county area.

Experience with computers

Half of all respondents had fewer than two years of experience working with computers (13/26). Six respondents had between two and four years of experience and seven respondents possessed five or more years of experience working with computers. One respondent did not specify.

As expected, a higher proportion of respondents with two or more years of computer experience (8/8) recently received a degree compared with the proportion of respondents with fewer than two years of computer experience (3/8). Analysis cannot easily explain this difference by chance alone (Fisher's Exact test p-value=0.03; analysis dichotomised at the medians responses for both the year the respondent received their most recent degree and years of computer experience). The greater level of computer literacy required to complete academic programmes in recent years may contribute to this difference.

When asked whether they have a computer at home, more than half of all respondents said yes (17/25). Eight respondents said they did not have a computer at home and two did not specify.

Use of computers for work related tasks

Before and after the pilot study period, researchers asked how many hours per week respondents used computers for work related tasks. Prior to the pilot study period, 12 respondents used computers for work related tasks fewer than five hours per week. Eight respondents used computers between 5-10 hours per week, and six used computers for work related tasks 10 or more hours per week (Range : 1-15 hours/week, $\bar{x}$=5.3 hours/week, n=26).

Following the pilot study period, 11 respondents used computers for work related tasks less than five hours per week, an equal number of respondents used computers 5-10 hours per week, and four used computers for work related tasks 10 or more hours per week(Range 1-20 hours/week, $\bar{x}$= 6.2 hours/week, n=26).

Post pilot study responses suggest several characteristics of respondents. A higher proportion of nurses who spent six or more hours per week using computers for work related tasks (8/9) received their most recent degree in the past 12 years compared with the proportion of nurses who used computers for fewer than six hours per week (0/7). Chance does not easily explain this finding (Fisher's Exact test p-value=0.001; the analysis dichotomised responses for number of hours computers used for work related tasks at the median).

The finding may refer to nurses' attitude towards learning: recent graduates may have more enthusiasm for developing new skills compared with those who graduated more than 12 years ago.

Alternately, the finding may also refer to a nurse's comfort level with using computers: nurses with greater experience using computers may feel less inhibited working with them and, hence, spend more time using them. Eight of eleven respondents who used computers for work related tasks fewer than six hours/week had less than two years of computer experience compared with 2/12 who used computers six or more hours/week.

A nurse who spent fewer than six hours per week using computers for work related tasks was 13 times more likely to have fewer than two years of experience using computers compared with a nurse who used computers for six or more hours per week (OR 13.3 95% C.I. 1.3-190.3; the researcher dichotomised at the median both: responses for number of hours computers used for work related tasks; and responses for number of years experience working with computers).

The author's personal observation supports this finding. During the pilot study, several individuals who felt less comfortable with computer use initially delayed using the Postpartum Client Record system for several days.

Due to limitations in sample size, analysis could not determine if the amount of computer experience explains the association between when a nurse last graduated and the number of hours she uses a computer for work related tasks. Regardless, future computer integration programmes will also need to specifically address individuals with fewer years of computer experience.

The analysis matched and compared the pre-pilot and post-pilot period responses of each nurse who participated in both surveys. The researcher considered any differences in the number of hours per week that respondents reported using computers immediately before and after the pilot study period. Ten of twelve non-pilot study participants decreased the number of hours they used computers for work related tasks compared with 4/12 pilot study participants. As expected, a non-pilot study participant was ten times more likely to decrease the number of hours per week she used computers for work related tasks compared with a pilot study participant (OR 10.0 95% C.I. 1.1-120.0). Other factors may explain this difference, however analysis cannot rule out their interaction because of limitations in sample size.

Use of computers for non-work related tasks

Nurses also noted how many hours per week they used computers for non-work related tasks before and after the pilot study period. Prior to the pilot study period, eight respondents did not use a computer for non-work related tasks. Thirteen nurses used computers 0-3 hours per week, while four used computers 3-7 hours per week (Range 0-7 hours/week, $\bar{x}$=1.5 hours/week, n=25).

When asked before the pilot period, a higher proportion of respondents who received a degree in the past 12 years (5/7) also used a computer for non-work related tasks for more than one hour per week compared with respondents who received a degree more than 12 years ago (1/8). Analysis excluded chance as a likely explanation. The finding may relate to a greater exposure to computer use in university in recent years (Fisher's Exact test p-value=0.04; analysis dichotomised responses at the median year the respondent most recently received a degree).

Following the pilot study period, nearly twice as many respondents (n=15) said they had not used a computer for non-work related tasks, while eight respondents used computers 0-3 hours per week. Three nurses used computers 3-7 hours per week for non-work related tasks (Range 0-7 hours/week, $\bar{x}$=1.0 hours/week, n=26).

Training

Prior to the pilot study period, nurses revealed how many hours of computer training they had received in the past 12 months. Two respondents said they had not received any computer training. Five respondents said they had received 0-5 hours of training, 13 felt they had received 5-10 hours of training and six said they had received 10 or more hours of training (Range 0-24 hours, $\bar{x}$=7.6 hours, n=26).

Views on Perinatal Information Management

In this section, the questionnaire requested respondents rate how much they agreed with thirteen statements that described different aspect of perinatal information management.

Efficiency

Respondents rated two statements concerning perinatal information management. First, PHNs considered the following statement:

> "Overall, Public Health Services' perinatal information is managed *efficiently*."

In the pre-pilot period survey, 15 respondents felt they either "strongly agreed" or "somewhat agreed", nine respondents either "somewhat disagreed" or "strongly disagreed" and three respondents "neither disagreed nor agreed" (Median=4, n=27). See Figure 1.

In the post-pilot period survey, six respondents either "strongly agreed" or "somewhat agreed" Public Health Services' prenatal information is managed efficiently. Ten respondents either "somewhat disagreed" or "strongly disagreed" and ten respondents "neither disagreed nor agreed" (Median=3, n=26). Please refer to Figure 1.

Second, respondents responded to the statement:

"Overall, inter-agency perinatal information is managed *efficiently*."

In the pre-pilot survey, nine respondents "somewhat agreed" while 13 respondents either "somewhat disagreed" or "strongly disagreed". Five respondents "neither disagreed nor agreed" (Median=3, n=27). Please refer to Figure 2.

When asked before the pilot period, a higher proportion of respondents with RN-Baccalaureate or RN-Master's level education disagreed that inter-agency perinatal information is efficiently managed (10/14) compared with respondents with LPN or RN-Diploma level education (0/8). Analysis suggests chances does not easily explain this difference (Fisher's Exact test p-value=0.002).

In the post-pilot survey, five respondents either "strongly agreed" or "somewhat agreed" that agencies efficiently manage perinatal information between them. Thirteen respondents either “somewhat disagreed” or “strongly disagreed” and eight felt they “neither disagreed nor agreed” (Median=2.5, n=26). See Figure 2.

Convenience

With respect to convenience, respondents considered whether they agreed with the statement:

> “Overall, the current perinatal information system allows me to get information when ever I need it.”

The pre-pilot survey found six nurses “somewhat agreed” with the statement while 11 either “somewhat disagreed” or “strongly disagreed” that current system allowed timely access to perinatal information. Ten nurses “neither disagreed nor agreed” (Median=3, n=27). See Figure 3.

In the post-pilot survey, five respondents “somewhat agreed” that the current system permitted timely access to perinatal information. Eleven respondents either “somewhat disagreed” or “strongly disagreed” with the statement and ten nurses “neither disagreed nor agreed” (Median=3, n=26). Please refer to Figure 3.

Accuracy and legibility

The questionnaire asked nurses to consider several statements related to the quality of information available in the current perinatal information system.

Concerning data displayed on client charts, nurses responded to the statement:

“Overall, perinatal information found on client charts is always *accurate*.”

Before the pilot study period, 12 nurses either “strongly agreed” or “somewhat agreed” with the statement while nine felt they either “somewhat disagreed” or “strongly disagreed”. Six nurses “neither disagreed nor agreed” with the statement (Median=3, n=27). Please refer to Figure 4.

When asked before the pilot period, a higher proportion of respondents who used computers less than five hours per week for work related tasks did not believe perinatal information found on client charts is always accurate (6/10), compared with respondents who used computers for five or more hours per week (2/13). Analysis does not easily attribute these findings to chance alone (Fisher’s Exact test p-value=0.04; analysis dichotomised at the median responses for number of hours/week nurses computers used for work related tasks).

After the pilot study period, eight respondents either “strongly agreed” or “somewhat agreed” that perinatal client charts are always accurate. Ten respondents either “somewhat disagreed” or “strongly disagreed” and eight “neither disagreed nor agreed” (Median=3, n=26). Please refer to Figure 4.

Among pilot study participants, the median respondent decreased her agreement with the statement (Wilcoxon Signed Rank Test p-value=0.036). Responses of nurses who did not participate in the pilot study did not show this difference. The decrease in belief in the accuracy of perinatal information may have arisen from pilot system data errors resulting from key-in mistakes. As well, pilot study participants may have become more aware of client charts inaccuracies, since the pilot study placed a greater emphasis on information management.

Concerning missing information, respondents considered the statement:

> "There is often information missing from a perinatal client's records."

Responses gathered before the pilot study period suggest 15 nurses either "strongly agreed" or "somewhat agreed" with the statement while five respondents either "somewhat disagreed" or "strongly disagreed". Seven respondents "neither disagreed nor agreed" (Median=4, n=27). See Figure 5.

Respondents felt similarly after the pilot period. Seventeen nurses either "strongly agreed" or "somewhat agreed". Five respondents either "somewhat disagreed" or "strongly disagreed" and four respondents "neither disagreed nor agreed" (Median=4, n=26). Please refer to Figure 5.

Concerning the legibility of information, nurses rated the statement:

> "With the current perinatal information system, illegible information often leads to error or delays."

Before the pilot study period, 12 respondents either "strongly agreed" or "somewhat agreed” with the statement in contrast to seven individuals who “somewhat disagreed”. Eight nurses “neither disagreed nor agreed”. The median nurse respondent felt neutral to the statement (Median=3, n=27). See Figure 6.

After the pilot study period, 11 nurses either “strongly agreed” or “somewhat agreed” with the statement. Four individuals either “somewhat disagreed” or “strongly disagreed” with the statement and 11 “neither disagreed nor agreed” that illegible information often leads to error or delays in the current system. The median nurse felt neutral to the statement (Median=3, n=26). Please see Figure 6.

Information accessibility

In terms of the accessibility of perinatal information in the system, nurses gave their opinion about the following statement:

> “The current perinatal information system prevents information from flowing quickly between co-workers.”

Before the pilot study period, nine nurses either “strongly agreed” or “somewhat agreed” with the statement while ten either “somewhat disagreed” or “strongly disagreed”. Eight respondents “neither disagreed nor agreed” with the statements. The median nurse neither agreed nor disagreed that the current system prevents information from flowing quickly between co-workers (Median=3, n=27). Please refer to Figure 7.

Responses after the pilot study period reflect similar perceptions. Nine nurses either “strongly agreed” or “somewhat agreed”. Eight respondents either “somewhat disagreed” or “strongly disagreed” and nine “neither disagreed nor agreed”. Analysis found similar median responses before and after the pilot study period (Median=3.0, n=26). See Figure 7.

Time consumed by clerical work

Regarding time consumed by clerical work, respondents considered the statement:

> “In the current perinatal information system, clerical work consumes a major portion of my time.”

Before the pilot study period, 20 nurses either “strongly agreed” or “somewhat agreed” with the statement while three either “somewhat disagreed” or “strongly disagreed”. Four nurses “neither disagreed nor agreed” with the statement. The median response strongly agreed that perinatal clerical work consumes a major portion of their time (Median=5, n=27). See Figure 8.

When asked before the pilot period, a higher proportion of respondents with LPN or RN-Diploma level education disagreed that clerical work consumes a major portion of her time in the current perinatal system (3/8), compared with respondents possessing RN-Baccalaureate or RN-Masters level education (0/14). Chance does not easily explain this difference alone (Fisher’s Exact test p-value=0.04).

When asked following the pilot study period, 21 nurses either “strongly agreed” or “somewhat agreed” with the statement. Only a single nurse felt she strongly disagrees with the statement and four “neither disagreed nor agreed”. Median pre-pilot and post-pilot responses suggested little change in attitude: respondents strongly agreed that perinatal clerical work consumes a major portion of their time (Median=5, n=26). Please see Figure 8.

Loss of information

Concerning loss of information, nurses responded to the statement:

> “In the current perinatal information system, documents (eg. client records) are never lost.”

Prior to the pilot study period, ten nurses either “strongly agreed” or “somewhat agreed” with the statement while seven nurses either “somewhat disagreed” or “strongly disagreed”. Ten individuals “neither disagreed nor agreed” with the statement. The median nurse response neither disagreed nor agreed that users of the current system never lose documents (Median=3, n=27). Please refer to Figure 9.

When asked before the pilot study period, a higher proportion of younger respondents disagreed that current perinatal information system users never lose documents (4/7) compared with older respondents (1/13). Analysis does not easily attribute this difference to chance alone (Fisher Exact test p-value=0.03; analysis binomialised nurses’ ages at the median).

As described above, respondents disclosed the number of hours per week they used computers for work related tasks following the pilot study period. A higher proportion of respondents who disagreed that users never lose documents in the current system used computers six or more hours per week for work related tasks (7/13), compared with respondents who did believe (0/11). Chance can not easily account for this difference alone (Fisher's Exact test p-value=0.006; analysis dichotomised responses for number of hours computers used for work related tasks at the median). Although the Woolf's Test precludes explanation by participation in the pilot study (Woolf's χ^2 Test for Interaction p-value=0.79), sample size limitations do not allow testing other factors to account for the difference.

Following the pilot study period, a smaller proportion of nurses felt users of the current perinatal information system never lose documents. Only four nurses either "strongly agreed" or "somewhat agreed" with the statement. Eleven respondents either "somewhat disagreed" or "strongly disagreed" while eleven individuals "neither disagreed nor agreed" with the statement. The median response after the pilot study period neither disagreed nor agreed that users never lose perinatal information in the current system (Median=3, n=26). Please refer to Figure 9.

Timeliness

Respondents rated the following statement:

"The current perinatal information system allows us to always address client needs with in the time suggested by our organisation's practise guidelines."

Before the pilot study period, 12 nurses either "strongly agreed" or "somewhat agreed" with the statement, while an equal number either "somewhat disagreed" or "strongly disagreed" with the statement. Three respondents "neither disagreed nor agreed" with the statement.

The median response somewhat disagreed that the current system allows them to address client needs in the time frame suggested by Public Health Services' practise guidelines (Median=2.5, n=27). Please see Figure 10.

After the pilot study period, 13 nurses either "strongly agreed" or "somewhat agreed" with the statement. Seven respondents either "somewhat disagreed" or "strongly disagreed" with the statement and six "neither disagreed nor agreed". Please refer to Figure 10.

In contrast to the median response before the pilot study, the median response following the study neither disagreed nor agreed that the current system allowed them to address client needs in the time frame suggested by Public Health Services' practise guidelines (Median=3, n=26).

Multi-user access

In view of the accessibility of information to multiple users, the questionnaire posed the following statement:

> “The current perinatal information system allows the same information to be available to several users at a time.”

Prior to the pilot study, only two nurses “somewhat agreed” with the statement while 17 nurses either “somewhat disagreed” or “strongly disagreed” with the statement. Eight respondents “neither disagreed nor agreed” with the statement. The median response somewhat disagreed that the current system permitted multiple users to access the same information at any given time (Median=2, n=27). See Figure 11.

Following the study, six respondents either “somewhat agreed” or “strongly agreed” with the statement. Fourteen nurses either “somewhat disagreed” or “strongly disagreed” and six “neither disagreed nor agreed” with the statement. The median response after the pilot period also disagreed with the statement that the current system permitted simultaneous, multiple user accessibility of information (Median=2, n=26). Please refer to Figure 11.

After the pilot period, a higher proportion of younger respondents disagreed that the current system makes the same information available to several users at a time (7/7) compared with older respondents (5/13). Analysis does not attribute this difference to chance alone (Fisher’s Exact test p-value=0.02; analysis binomialised nurses’ ages at the median). It is important to note that public health nursing experience may play a role: when the researcher contrasted the same statement responses with the number of years experience as a Public Health Nurse, analysis could barely attribute the observed difference to chance at the 95% confidence level (Fisher's Exact test p-value=0.07). Again, sample size precluded analysis to confirm the interaction of such factors.

Organisational Planning

Concerning short-term planning, respondents considered the statement:

> "The current system allows perinatal information which is collected to be used for short-term organisational planning."

Before the pilot study period, 11 nurses "somewhat agreed" with the statement while seven respondents either "somewhat disagreed" or "strongly disagreed". Nine nurses "neither disagreed nor agreed" with the statement. The median response neither disagreed nor agreed with the statement that the current system facilitated the current use of perinatal information for short-term organisational planning (Median=3, n=27). See Figure 12.

Prior to the pilot study period, a higher proportion of younger respondents disagreed that the current system allows the use of collected perinatal information for short-term organisational planning (4/7), compared with older respondents (1/13). Chance cannot easily account for this difference (Fisher's Exact test p-value=0.03; the researcher binomialised nurses' ages at the median).

After the pilot study period, nine respondents either "strongly agreed" or "somewhat agreed" with the statement. Eight either "somewhat disagreed" or "strongly disagreed" with the statement and nine “neither disagree or agree”. The findings suggest a similar median response before and after the pilot period (Median=3.0, n=26). Please refer to Figure 12.

With respect to long-term planning, respondents considered the following:

> “The current system allows perinatal information which is collected to be used for long-term organisational planning.”

Prior to the pilot study period, six nurses either “strongly agreed” or “somewhat agreed” with the statement while eight either “somewhat disagreed” or “strongly disagreed”. Thirteen “neither disagreed nor agreed” with the statement. The median response before the pilot study neither disagreed nor agreed that the current system facilitates long-term planning from collected perinatal information (Median=3, n=27). See Figure 13.

Before the pilot period, a higher proportion of younger respondents (5/7) disagreed that the current system facilitates long-term planning from collected perinatal information, compared with older respondents (1/13). A younger respondent was 30 times more likely to have disagreed with the statement, compared with older respondents (OR 30.0 95% C.I. 1.6-1531.0; analysis dichotomised nurses’ ages at the median).

Following the pilot study period, 13 nurses either “strongly agreed” or “somewhat agreed” the current system facilitates long-term organisational planning. Six respondents either “somewhat disagreed” or “strongly disagreed” while seven “neither disagreed nor agreed”. The median response following the pilot period neither disagreed nor agreed with the statement (Median=3.5, n=26). See Figure 13.

Overall acceptance of the perinatal information system

Analysis scored responses related to all perinatal information management statements for degree of acceptance. Scoring of negative statements occurred inversely (1=5, 2=4, 3=3, 4=2, 5=1) while responses to positive statements remained unchanged (1=1, 2=2, 3=3, 4=4, 5=5). Summation of scores for all related statements produced an overall indicator of the respondent’s acceptance of the current perinatal information system. This process yielded an overall indicator of acceptance for both pre-pilot and post-pilot period responses.

The researcher then dichotomised these summary indicator at the median, such that: *above median* = indicator rating in the top 50th percentile and *below median* = indicator rating in the bottom 50th percentile. Contrasting of the dichotomised indicator with other factors followed.

Analysis detected differences in a respondent’s overall pre-pilot study acceptance of the current perinatal information system among respondents of different age groups and education levels. Six of seven younger respondents rated the current perinatal information system as below median, compared with 3/13 older respondents. A younger respondent was 20 times more likely to give the current perinatal information system a below median rating of acceptance compared with an older respondent (OR 20.0 95% C.I. 1.3 - 1008.5). Also, a lower proportion of respondents with a LPN or RN-Diploma education level (1/8) rated the current perinatal information system a *below median* rating of acceptance compared with respondents possessing RN-Baccalaureate or RN-Master's level education (9/14). Significance tests do not attribute these findings to chance alone (Fisher's Exact test p-value=0.03).

Although analysis detected differences among these groups before the pilot study, analysis of post-pilot study responses did not yield the same results even when the analysis considered participation in the pilot study. It is not clear what might have influenced this change following the pilot study period.

Views on Computers

Training

Respondents rated several statements to assess their opinion of training. Concerning the sufficiency of training, respondents considered the statement:

> "Overall, I felt I did not receive enough training to use the current *computer* system."

Before the pilot study period, 14 nurses either "strongly agreed" or "somewhat agreed" with the statement while four nurses either "somewhat disagreed" or "strongly disagreed". Nine respondents "neither disagreed nor agreed" with the statement. The median response before the pilot study neither disagreed nor agreed that they did not receive enough training to use the computer system (Median=3.5, n=27). Please refer to Figure 14.

Following the pilot study period, 16 nurses either “strongly agreed” or “somewhat agreed” with the statement suggesting they did not receive enough training to use the current computer system. Four nurses either “somewhat disagreed” or “strongly disagreed” with the statement while five “neither disagreed nor agreed”. The median response following the pilot period somewhat agreed with the statement (Median=4, n=25). Please see Figure 14.

Concerning the timeliness of training, respondents rated the following statement:

> “Training was offered soon enough to prepare me to use the current *computer* system when I needed to.”

Prior to the pilot study period, four respondents either “strongly agreed” or “somewhat agreed” with the statement while 18 respondents either “somewhat disagreed” or “strongly disagreed”. Five “neither disagreed nor agreed” with the statement. The median response before the pilot study somewhat disagreed with the statement (Median=2, n=27). See Figure 15.

Before the pilot study period, a higher proportion of respondents who received fewer than seven hours of computer training (8/8) felt the training offer occurred too late to prepare her to use the computer system when she needed, compared with respondents who received seven or more hours of computer training (7/15). Significance tests cannot easily account for this difference by chance (Fisher's Exact test p-value=0.02; dichotomisation of responses for the number of training hours received in the past 12 months occurred at the median).

Because of the role many Public Health Nurses play in inter-agency organisations, committees and the client population, a Public Health Nurse's daily work schedule can vary radically. Some respondents may not have attended initial offerings of computer training sessions; instead, they attended later training sessions and thus missed training before it was needed.

Following the pilot study period, seven respondents either "strongly agreed" or "somewhat agreed" with the statement. Fourteen respondents either "somewhat disagreed" or "strongly disagreed" and five neither disagreed nor agreed that implementers offered timely training for the current computer system. Even after the pilot study period, the median response somewhat disagreed that timely training was offered for the current computer system (Median=2.5, n=26). Please see Figure 15.

Concerning the impact of training required for computer use, respondents rated the following statement:

"Orientation for new employees takes longer because of computers and, therefore, unnecessary work delays occur."

Prior to the pilot study period, none of the respondents agreed with the statement, while 17 either "somewhat disagreed" or "strongly disagreed". Ten nurses "neither disagreed nor agreed" with the statement. The median response before the pilot study somewhat disagreed that orientation of new staff would take longer because of computers, resulting in unnecessary work delays (Median=2.0, n=27). Please refer to Figure 16.

After the pilot study period, three respondents either "strongly agreed" or "somewhat agreed" with the statement. Compared with pre-pilot period responses, fewer nurses disagreed with the statement (n=9), while 14 "neither disagreed nor agreed". The median response following the pilot period neither disagreed nor agreed with the statement (Median=3, n=26). Please see Figure 16.

Concerning self-evaluation of the respondents' ability to be trained, respondents considered the statement:

"Compared with my co-workers, I am slow at learning how to use the computer."

Prior to the pilot study period, nine nurses either "strongly agreed" or "somewhat agreed" with the statement, while 17 either "somewhat disagreed" or "strongly disagreed". Only one "neither disagreed nor agreed" with the statement. The median response somewhat disagreed that they felt they took longer to acquire computer skills compared with co-workers (Median=2, n=27). Please see Figure 17.

When asked before the pilot period, three of ten respondents with less computer experience disagreed with the statement compared with 11/13 respondents with more computer experience. As expected, a nurse with less computer experience was over 12 times more likely to feel she is slow at learning how to use a computer compared with one with more computer experience (Odds ratio 12.83 95% C.I. 1.3-167.7; dichotomisation of responses for the number of years experience working with computers occurred at the median). Due to limitations in sample size, analysis could not eliminate other factors as possible explanations for this association.

Assuming analysis cannot attribute this difference to other factors, this difference seems expected since with more experience, one would predict increased confidence and less inhibition towards using computers. Trainers must place a greater focus on those with less experience with computers during both training and implementation.

Following the pilot study period, fewer nurses either agreed with the statement (n=6). As with pre-pilot period responses, 17 either “somewhat disagreed” or “strongly disagreed” with the statement. Three respondents “neither disagreed nor agreed” with the statement that they were slow at acquiring computer skills compared with co-workers. Analysis found similar pre-pilot and post-pilot median responses(Median=2, n=26). Please see Figure 17.

Cost

Concerning nurses perceptions of computers, nurses rated the following statement:

"A computer increases costs by increasing a nurse's workload."

Before the pilot study period, ten nurses either "strongly agreed" or "somewhat agreed" with the statement, while an equal number of nurses either "somewhat disagreed" or "strongly disagreed" with the statement. Seven respondents "neither disagreed nor agreed" with the statement. The median response before the study neither disagreed nor agreed that computers increase cost by increasing a nurse's workload (Median=3, n=27) Please see Figure 18.

When asked prior to the pilot period, 7/8 respondents who received a degree more recently disagreed with the statement compared with 1/8 respondents who received a degree less recently. A nurse who received a degree in the past 12 years was 49 times more likely to disagree that computers increase costs by increasing a nurse's workload compared with a nurse with a less recent degree (OR 49.0 95% C.I. 1.8-2508.2; response dichotomisation for the year they received their most recent degree occurred at the median). Due to limitations in sample size, analysis could not exclude other factors as possible explanations.

In the context of the increasing presence of computers in academic programmes in recent years, recent graduates would have had greater exposure to the potential benefits of computers in decreasing both costs and workload. The finding emphasises the importance of developing an implementation strategy that promotes both the motivation behind computerising the work process and proven benefits anticipated *from* the integration process.

After the pilot study period, ten nurses either “strongly agreed” or “somewhat agreed” that computers increased costs by increasing a nurse’s workload. Seven nurses either “somewhat disagreed” or “strongly disagreed” while nine “neither disagreed nor agreed” with the statement. Analysis detected similar median responses before and after the pilot period (Median=3, n=26). Please see Figure 18.

In the comparison of pre- and post-pilot period responses, the researcher looked for any changes in how much a respondent agreed with each statement. Finding suggest a difference between pilot study participants and non-participants regarding their perceptions of whether computers increase costs by increasing a nurse’s workload. Nine of twelve non-pilot study participants decreased their agreement with the statement that computers increase costs by increasing nursing workloads, compared with 3/12 pilot study participants. A non-pilot study participant had a nine fold greater likelihood of decreasing her acceptance of the statement that computers increase costs by increasing a nurse’s workload, compared with a pilot study participant (OR 9.0 95% C.I. 1.1-98.1). Limitations in sample size restrict the examination of other factors that may explain this difference.

Failing explanation by other factors, this difference may have arisen because collection of post-pilot responses occurred before pilot study participants had completed integrating the system into their daily work. Still in the process of learning the new system, pilot study participants may view the excess time currently required to fill out forms as costly.

The finding support this hypothesis. Throughout the pilot period, a pilot study participant had a lower likelihood of decreasing the number of hours spent using computers for work related tasks compared with non-pilot study participants (see Use of computers for work related tasks). One pilot study participant commented:

> "Palm [top] takes too long in home...there we must jot a few things down as we did before. If there were problems, we checked things off on a sheet and jotted notes next to it. Then put it on palm, then computer, then print. We still have to check computer read out."

Concerning time costs, nurses also rated the following statement:

> "Computers will allow a nurse more time for the professional tasks for which s/he is trained."

Prior to the pilot study, eight nurses either "strongly agreed" or "somewhat agreed" with the statement, while ten nurses either "somewhat disagreed" or "strongly disagreed". Nine "neither disagreed nor agreed" with the statement. The median response before the pilot study neither disagreed nor agreed that computers will permit nurses more time for the professional tasks s/he is trained to do (Median=3, n=27). Please see Figure 19.

Before the pilot period, a higher proportion of older respondents (7/13) disagreed that computers would allow nurses to have more time for the professional tasks s/he is trained to do, compared with younger respondents (0/7). Chance does not easily account for this difference (Fisher's Exact test p-value=0.04; response dichotomisation of nurses' ages occurred at the median), although analysis cannot exclude other factors as possible explanations due to limitations in sample size.

Following the pilot study, fewer nurses either "strongly agreed" or "somewhat agreed" with the statement (n=5). Thirteen nurses either "somewhat disagreed" or "strongly disagreed" with the statement while eight nurses "neither disagreed nor agreed" that computers will allow nurses more time for the professional tasks s/he has been trained to complete. The post-pilot period median response somewhat disagreed with the statement (Median=2.5, n=26). Please see Figure 19.

Regarding perceptions of the cost of computers, respondents rated the following statement:

"Part of the increase in costs of health care is because of computers."

Prior to the pilot study period, only one nurse "strongly agreed" with the statement, while 19 nurses either "somewhat disagreed" or "strongly disagreed". Seven "neither disagreed nor agreed" with the statement. The pre-pilot median respondent somewhat disagreed that part of the increase in health care costs resulted from computers (Median=2, n=27). Please see Figure 20.

Following the pilot study period, three nurses “somewhat agreed” with the statement. Compared with before the pilot study period, fewer respondents either “somewhat disagreed” or “strongly disagreed” with the statement (n=8), while 15 nurses “neither disagreed nor agreed” that computers partially accounted for the increase in health care costs. The median response following the pilot study neither disagreed nor agreed with the statement (Median=3, n=26). Please see Figure 20.

Related to the costs of computer use to staff efficiency, respondents rated the statement:

> “Only one person at a time can use a computer terminal and therefore, staff efficiency is inhibited.”

Before the pilot study period, more than half of all respondents (n=17) either “strongly agreed” or “somewhat agreed” with the statement. Five either “somewhat disagreed” or “strongly disagreed” with the statement, while an equal number “neither disagreed nor agreed” (n=5). The median response before the pilot study somewhat agreed that staff efficiency is inhibited because only one person at a time can use a computer terminal (Median=4, n=27). See Figure 21.

Following the pilot study period, an even larger number of respondents (n=19) either “strongly agreed” or “somewhat agreed” with the statement. Only three either “somewhat disagreed” or “strongly disagreed” and four “neither disagreed nor agreed” that staff efficiency is inhibited by the premise ‘only one person at a time can use a computer terminal’. Analysis identified similar pre-pilot and post-pilot median responses (Median=4, n=26). Please refer to Figure 21.

Communications

Concerning of the perceived benefit of computers towards inter-agency communications, respondents responded to the following statement:

“Computers cause a decrease in communication between health services.”

Before the pilot study period, five nurses either “strongly agreed” or “somewhat agreed” with the statement, while 17 nurses either “somewhat disagreed” or “strongly disagreed”. Five nurses neither disagreed nor agreed with the statement. The median response before the pilot study period somewhat disagreed that computers result in decreased communications between health services (Median=2, n=27). Please see Figure 22.

Prior to the pilot period, a higher proportion of younger respondents (7/7) disagreed that computers cause a decrease in communications between health services, compared with older respondents (5/13). Analysis suggests chance does not easily explain this difference (Fisher’s Exact test p-value=0.01; analysis grouped nurses’ ages above and below the median).

A nurse’s educational background may relate to her/his views on health services’ communication. Eleven of fourteen respondents with RN-Baccalaureate or RN-Master's level education disagreed with the statement, compared with 2/8 less educated respondents. A nurse with RN-Baccalaureate or RN-Masters level education was 11 times more likely to disagree that computers cause a decrease in communications between health services, compared with a nurse with a LPN or RN - Diploma education (OR 11.0 95% C.I. 1.1-147.6). Limitations in sample size limited the exclusion of other factors as possible explanations.

After the pilot study period, seven nurses either "strongly agreed" or "somewhat agreed" with the statement, while 11 nurses either "somewhat disagreed" or "strongly disagreed". Eight respondents neither disagreed nor agreed that computers cause a decrease in communications between health services. The median response after the pilot study period neither disagreed nor agreed with the statement (Median=3, n=26). Please refer to Figure 22.

Perceived benefit of computers

Concerning nurse perceptions of the value of computers in daily work, respondents rated the statement:

> "The time spent using a computer is out of proportion to the benefits."

Prior to the pilot study period, six respondents either "strongly agreed" or "somewhat agreed" with the statement, while 13 either "somewhat disagreed" or "strongly disagreed". Eight nurses "neither disagreed nor agreed" with the statement. The median response before the pilot period neither disagreed nor agreed that the time spent using a computer is out of proportion to the benefits (Median=3, n=27). Please refer to Figure 23.

Following the pilot study period, slightly more respondents either “strongly agreed” or “somewhat agreed” with the statement (n=9), while fewer respondents disagreed with the statement (six nurses “somewhat disagreed”). Eleven respondents “neither disagreed nor agreed” that the time consumed using a computer outweigh the benefits. The pre-pilot and post-pilot median responses appeared similar (Median=3, n=26). Please see Figure 23.

Respondents also rated the following statement concerning the benefits of computer use:

> “Computerisation of nursing data offers nurses a remarkable opportunity to improve patient care.”

Prior to the pilot study period, 12 respondents either “strongly agreed” or “somewhat agreed” with the statement, while only three “somewhat disagreed”. Twelve nurses responded “neither disagreed nor agreed” with the statement. The median response neither disagreed nor agreed with the statement (Median=3, n=27). Please see Figure 24.

Before the pilot period, a higher proportion of LPN or RN-Diploma educated respondents (3/8) disagreed that computerisation of nursing data could greatly improve patient care, compared with RN-Baccalaureate or RN-Masters educated respondents (0/14). Chance does not easily account for this difference (Fisher's Exact test p-value=0.04).

After the pilot study period, fewer nurses (n=8) either "strongly agreed" or "somewhat agreed" with the statement. Compared with before the pilot period, considerably more respondents (n=9) either "somewhat disagreed" or "strongly disagreed" that computerisation of nursing data offered a great opportunity to improve patient care. An equal number of respondents (n=9) "neither disagreed nor agreed" with the statement. Analysis found similar pre-pilot and post-pilot median responses (Median=3, n=26). Please refer to Figure 24.

Respondents also rated the statement:

"Computers cause nurses to give less time to quality patient care."

Prior to the pilot study period, only three respondents either "strongly agreed" or "somewhat agreed" with the statement, while 17 either "somewhat disagreed" or "strongly disagreed". Seven nurses "neither disagreed nor agreed" with the statement. The median pre-pilot response somewhat disagreed that computers detract from time allotted to quality patient care (Median=2, n=27). Please refer to Figure 25.

When surveyed before the pilot period, answers suggest several characteristics about those nurses who rated this statement. A higher proportion of younger respondents (7/7) disagreed with the statement that computers cause nurses to give less time to quality patient care, compared with older respondents (6/13). Analysis excluded chance as an explanation for this difference (Fisher's Exact test p-value=0.04; response dichotomisation of nurses' ages occurred at the median). Perhaps younger respondents have had more exposure to positive, time saving applications of computers than older respondents.

Eleven of thirteen nurses with two or more years of computer experience disagreed with the statement compared with 3/10 nurses with less than two years of computer experience. A respondent with two or more years of computer experience had a 12 fold greater likelihood of disagreeing with the statement compared with a respondent who possessed fewer than two years of computer experience (OR 12.8 95% C.I. 1.3-181.5; analysis binomialised responses for years of computer experience above and below the median).

As well, 13/17 respondents who had a home computer disagreed with the statement compared with 1/5 respondents who did not. A respondent who had a computer at home was 16 times more likely to disagree with the statement that computers cause nurses to give less time to quality patient care, compared with a respondent who did not (OR 16.3 95% C.I. 1.1-825.5). Limitations in sample size restrict the exclusion of other factors as explanations.

With the assumption that other factors could not explain any of these findings, results suggest facilitators of computer implementation programmes need to promote the benefits of computerisation to those nurses who are older in age, possess less computer experience and do not have a computer at home.

Following the pilot study period, considerably more respondents (n=8) either “strongly agreed” or “somewhat agreed” that computers detract from time allotted to quality patient care. Eight respondents also either “somewhat disagreed” or “strongly disagreed” with the statement, while ten “neither disagreed nor agreed”. Please refer to Figure 25.

The post-pilot median response neither disagreed nor agreed with the statement (Median=3, n=26).

Also concerning the perceived benefit of computers, nurses responded to the statement:

> “Computers make nurses[’] jobs easier.”

Before the pilot study period, nine respondents either “strongly agreed” or “somewhat agreed” with the statement, while seven either “somewhat disagreed” or “strongly disagreed”. The largest proportion of respondents “neither disagreed nor agreed” with the statement. The median pre-pilot response also neither disagreed nor agreed that computers make nurses' jobs easier (Median=3, n=27). Please refer to Figure 26.

Following the pilot study period, fewer respondents agreed with the statement ("somewhat agreed" n=6), while nine respondents either "somewhat disagreed" or "strongly disagreed". A similar number of respondents "neither disagreed nor agreed" with the statement that computers make nurses' jobs easier (n=11). The pre-pilot and post-pilot median responses appeared similar (Median=3, n=26). See Figure 26.

Concerning the impact of computers on paperwork, respondents rated the statement:

> "Paperwork for nurses has been greatly reduced by the use of computers."

Prior to the pilot study period, five nurses "somewhat agreed" with the statement, while 12 either "somewhat disagreed" or "strongly disagreed". Ten respondents "neither disagreed nor agreed" with the statement. The median pre-pilot response neither disagreed nor agreed that computer use has resulted in a great reduction in nursing paperwork (Median=3, n=27). Please refer to Figure 27.

After the pilot study period, five nurses either "strongly agreed" or "somewhat agreed" with the statement. Fifteen nurses either "somewhat disagreed" or "strongly disagreed" and six "neither disagreed nor agreed" with the statement that using computers has resulted in great reductions in paperwork. The post-pilot median response somewhat disagreed with the statement (Median=2, n=26). Please see Figure 27.

Respondents also rated the statement:

"Computers save steps and allow the nursing staff to become more efficient."

Prior to the pilot study period, 11 nurses either "strongly agreed" or "somewhat agreed" with the statement. Eight nurses either "somewhat disagreed" or "strongly disagreed", and an equal number of nurses "neither disagreed nor agreed" with the statement that computers save steps and increase nursing staff efficiency. The pre-pilot median response neither disagreed nor agreed with the statement (Median=3, n=27). See Figure 28.

When asked before the pilot period, a greater proportion of older respondents (7/13) disagreed that computers save steps and allow nursing staff to become more efficient, compared with younger respondents (0/7). Findings suggest that chance does not easily explain this difference (Fisher's Exact test p-value=0.04; response dichotomisation of nurses ages' occurred at the median). As with the statement concerning time available for patient care, perhaps younger nurses receive greater exposure to positive, work-minimising computer applications compared with older nurses.

Following the pilot study period, fewer nurses agreed with the statement ("somewhat agreed" n=3). Compared with pre-pilot period responses, more nurses disagreed (n=12) with the statement. Eleven nurses "neither disagreed nor agreed" with the statement that computers save steps and increase nursing staff efficiency. Please see Figure 28.

The post-pilot median response appeared similar to the pre-pilot one (Median=3, n=26).

With respect to the impact on patient care, nurses responded to the statement:

"Increased computer usage will allow nurses more time to give patient care."

Prior to the pilot study period, eight nurses either "strongly agreed" or "somewhat agreed" with the statement, while ten either "somewhat disagreed" or "strongly disagreed". Nine respondents "neither disagreed nor agreed" with the statement. The median response neither disagreed nor agreed that increased computer utilisation would alleviate greater time for patient care (Median=3, n=27). Please see Figure 29.

Following the pilot study period, only one nurse "strongly agreed" with the statement (no nurses "somewhat agreed"). Sixteen nurses either "somewhat disagreed" or "strongly disagreed" with the statement, while nine "neither disagreed nor agreed". The post-pilot median response somewhat disagreed with the statement (Median=2, n=26). Please refer to Figure 29.

Privacy

Concerning privacy, the researcher asked nurses to rate the statement:

"Computers represent a violation of patient privacy."

Before the pilot study period, six nurses either "strongly agreed" or "somewhat agreed" with the statement, while 12 either "somewhat disagreed" or "strongly disagreed". Nine “neither disagreed nor agreed” that computers represent a violation of patient privacy. The middle pre-pilot response neither disagreed nor agreed with the statement (Median=3, n=27). Please refer to Figure 30.

After the pilot study period, nine respondents either “strongly agreed” or “somewhat agreed” with the statement. Ten respondents either “somewhat disagreed” or “strongly disagreed” with the statement, while six “neither disagreed nor agreed”. Analysis detected similar median pre-pilot and post-pilot responses (Median=3, n=25). Please see Figure 30.

Respondents also rated the statement:

> “Computers contain too much personal data to be used in an area as open as a nursing station.”

Prior to the pilot study period, five nurses either “strongly agreed” or “somewhat agreed” with the statement, while thirteen respondents either “somewhat disagreed” and “strongly disagreed”. Nine respondents “neither disagreed nor agreed” with the statement. The median pre-pilot response neither disagreed nor agreed that computers contain too much personal data for use at a nursing station (Median=3, n=27). Please refer to Figure 31.

After the pilot study period, several more nurses (n=9) either “strongly agreed” or “somewhat agreed” with the statement. Eleven nurses either “somewhat disagreed” or “strongly disagreed” with the statement, while six “neither disagreed nor agreed”. The median pre-pilot and post-pilot responses appeared similar (Median=3, n=26). Please refer to Figure 31.

Receptiveness to the integration of computers

Several statements assessed the receptiveness of respondents to the integration of computers into daily work. First, nurses rated the statement:

> “If I had my way, nurses would not ever have to use computers.”

Prior to the pilot study period, only one respondent “somewhat agreed” with the statement, while 23 either “somewhat disagreed” or “strongly disagreed”. Three nurses “neither disagreed nor agreed” with the statement. The median pre-pilot response strongly disagreed with the statement (Median=1, n=27). Please refer to Figure 32.

As expected, when asked before the pilot period, a greater proportion of nurses with a home computer (16/17) disagreed with the statement compared with nurses without a home computer (3/6). Chance does not easily explain this difference in proportions (Fisher’s Exact test p-value=0.04).

Following the pilot study period, a single respondent also “somewhat agreed” with the statement. Compared with pre-pilot period responses, fewer nurses disagreed with the statement (“strongly disagreed”/ “somewhat disagreed” n=18). Seven respondents “neither disagreed nor agreed” that they would prefer not ever to use computers. The median post-pilot response also strongly disagreed with the statement (Median=1, n=26). Please refer to Figure 32.

Respondents also considered the statement:

"Computers should only be used in the financial department."

Before the pilot study period, none of the respondents agreed with the statement, and 23 respondents either "somewhat disagreed" or "strongly disagreed". Four respondents "neither disagreed nor agreed" with the statement. The median pre-pilot response strongly disagreed that computers should only be used in the financial department (Median=1, n=27). See Figure 33.

No respondents also agreed with the statement following the pilot study period. Fewer than before the pilot study period (n=19) either "somewhat disagreed" or "strongly disagreed" with the statement, while seven respondents "neither disagreed nor agreed". The median pre-pilot and post-pilot responses appeared similar (Median=1, n=26). Please refer to Figure 33.

Regarding the compatibility of nursing data for computers, respondents rated the statement:

"Nursing data does not lend itself to computers."

Prior to the pilot study period, only one nurse "somewhat agreed" with the statement, while 20 either "somewhat disagreed" or "strongly disagreed". Six nurses "neither disagreed nor agreed" with the statement. Please refer to Figure 34. The median pre-pilot response somewhat disagreed with the statement (Median=2, n=27).

Following the pilot study period, three nurses either "strongly agreed" or "somewhat agreed". Compared with pre-pilot period responses, fewer nurses disagreed with the statement (n=14). Nine "neither disagreed nor agreed" with the statement that computers are incompatible for use with nursing data. The median post-pilot response appeared similar to the pre-pilot one (Median=2, n=26). Please see Figure 34.

The researcher also asked nurses to rate the statement:

"The more computers in an institution, the less number of jobs for employees."

Prior to the pilot study period, four nurses "somewhat agreed" with the statement, while 15 either "somewhat disagreed" or "strongly disagreed". Eight nurses "neither disagreed nor agreed" with the statement. The pre-pilot median response somewhat disagreed that a greater number of computers in an institution resulted in fewer jobs (Median=2, n=27). Please see Figure 35.

Following the pilot study period, five respondents either "strongly agreed" or "somewhat agreed" (four and one, respectively), while 13 either "somewhat disagreed" or "strongly disagreed". Eight nurses "neither disagreed nor agreed" that a greater number of computers in an institution resulted in fewer jobs. The post-pilot median response neither disagreed nor agreed with the statement (Median=3, n=26). Please refer to

Figure 35.

Law

Concerning the impact of computers on accountability, nurses were asked to rate this statement:

"Because of computers, nurses will face more lawsuits."

Prior to the pilot study period, only one respondent "somewhat agreed" with the statement (none "strongly agreed"), while 16 either "somewhat disagreed" or "strongly disagreed". Ten "neither disagreed nor agreed" that nurses will face more lawsuits on account of computers. The median response before the pilot study somewhat disagreed with the statement (Median=2, n=27). Please see Figure 36.

Following the pilot study period, two respondents "strongly agreed" with the statement (none "somewhat agreed"). Fourteen nurses either "somewhat disagreed" or "strongly disagreed" with the statement and ten "neither disagreed nor agreed". Analysis found similar pre- and post-pilot median responses (Median=2, n=26). See Figure 36.

Respondents rated their accordance with the statement:

"When possible, I try to avoid using a computer to complete a task."

Before the pilot study period, four respondents either "strongly agreed" or "somewhat agreed" with the statement, while 19 either "somewhat disagreed" or "strongly disagreed". Four nurses "neither disagreed nor agreed" with the statement that they try to avoid using a computer to complete a task. The median response prior to the pilot study somewhat disagreed with the statement (Median=2, n=27). Please see Figure 37.

As expected before the pilot period, a higher proportion of respondents with home computer (14/17) did not try to avoid using a computer to complete tasks, compared with respondent without home computers (2/6). Analysis suggests chance cannot easily explain this finding: having a computer at home may increase a nurse's comfort with and interest in using computers (Fisher's Exact test p-value=0.045).

After the pilot study period, fewer respondents agreed with the statement (n=2). Twenty nurses either "somewhat disagreed" or "strongly disagreed" and four "neither disagreed nor agreed" with the statement. Analysis detected similar pre-pilot and post-pilot median responses (Median=2, n=26). Please refer to Figure 37.

Overall view of computers

The analysis scored nurses' ratings of statements concerning computers in the workplace by degree of acceptance. The process scored responses to positive statements similarly (1=1, 2=2, 3=3, 4=4, 5=5), and negative statements inversely (1=5, 2=4, 3=3, 4=2, 5=1). Scores for each statement totalled to produce an overall indicator of the respondent's acceptance of computers in the workplace. Analysis generated an overall indicator for both pre-pilot and post-pilot period responses.

Dichotomisation of the overall view of computers indicator occurred at the median, such that: *above median* = indicator rating in the top 50th percentile and *below median* =

indicator rating in the bottom 50th percentile.

The years of experience as a public health nurse and education level of respondents may relate to their overall acceptance of computers. Nine of twelve respondents with 11 or more years experience as a public health nurse viewed computers in the workplace with *below median* acceptance compared with 2/9 respondents with fewer than eleven years of experience. A *more experienced* respondent held a ten fold greater likelihood of viewing computers with a *below median* level of acceptance compared with a *less experienced* respondent (OR 10.5 95% C.I. 1.01 - 140.57; analysis dichotomised responses to the number of years experience as a public health nurse at the median). Limitations in sample size excluded analysis to consider other factors as potential explanations for this relationship.
Education background may also play a role in a respondents' overall view of computers. Seven of eight respondents with a LPN/Diploma education level viewed computers in the workplace with a *below median* level of acceptance compared with 4/14 respondents with Baccalaureate/Master's education level. A respondent with a LPN or RN-Diploma education was 17 times more likely to view computers with a *below median* level of acceptance compared with a respondent with RN-Baccalaureate or RN-Masters level education (OR 17.5 95% C.I. 1.24 - 542.5). Again, sample size limitations precluded exploration of other factors as possible explanations.

The pilot study may have played a role in respondents' overall acceptance of computers in nursing. Among pilot study participants, median acceptance of computers score following the pilot study lowered from the median score before the study (Wilcoxon Signed Rank Test, p-value<0.01). Analysis did not detect this difference among non-participants. The stress and challenges of learning to use the pilot system may have contributed to the decrease in acceptance.

Management of the integration of computers

The study linked and compared pre- and post-pilot responses to several questions concerning the process of integrating computers into Public Health Services. The following section presents responses of only those nurses who participated in both the pre-pilot and post-pilot survey (n=24).

Notice to anticipate changes

The questionnaire asked nurses whether they felt they received adequate notice to prepare them for any changes that occurred during the process of integrating computers. Among non-pilot study participants (n=12) before the pilot period, eight nurses felt the system implementation process had given adequate notice for any changes that occurred. Four non-pilot study participants felt they had not received adequate notice. Responses following the pilot study period from non-pilot study participants appeared similar: eight had received adequate notice and four had not.

Among pilot study participants (n=12), prior to the pilot period nine nurses felt the implementation process had given adequate notice while three felt it had not given adequate notice. In contrast, following the pilot study period, six pilot study participants responded they had received adequate notice while an equal number felt they had not.

Opportunity to give feedback

The study asked nurses if they had received adequate opportunity to give feedback before and after the pilot study.

Among non-pilot study participants (n=12) prior to the pilot period, six respondents felt the implementation process had offered adequate opportunity for feedback, while an equal number of respondents felt it did not. These nurses responded similarly following the pilot study period: six felt they had received adequate opportunity to give feedback while six felt they had not.

Among pilot study participants (n=12) prior to the pilot period, eight nurses felt they had received adequate opportunity for feedback while four felt they had not. In contrast, following the pilot study, 11 participants felt they had received adequate opportunity for feedback while one participant felt she had not.

Annex 8 offers basic frequencies of responses in tabular format. A table summarises comments made by pilot study and non-pilot study participants in Annex 9: Computers in public health nursing - summary of comments.

3.5 Limitations

Only 37 public health nurses work in the Eastern Region's Public Health Services; four out of five (n=29) responded to the survey. Several limitations restrict conclusions drawn from the sample taken from this population.

Study design only permits generalisation of findings to the population the sample represents. As the study cannot account for the views of non-respondents, findings described in the Results section represent *only the respondents* and not all public health nurses in the Eastern Region.

When significance tests suggest a possible relationship between a factor and an outcome, a small sample greatly reduces the opportunity to determine the interaction of other factors (that is, in the case of confounding and effect modification). Hence, all findings that suggest an association exists between an outcome and a factor cannot exclude the role of other factors.

Small sample size also resulted in a decrease in the precision of findings. Although analysis confirmed the statistical significance (at the 95% confidence level) of all findings presented, nearly all descriptions of Odds ratio include large confidence intervals. Such findings carry greater potential for explanation by chance, compared with findings bearing smaller confidence intervals.

Using statements not chosen through a widely accepted procedure for generating a unidimensional attitudinal scale, the researcher constructed the summative rating score to describe the overall acceptance of the perinatal information system and views on computers. As such, the report does not detail the scores themselves but values dichotomised at the median.

3.6 Discussion

Comparison with past studies of attitude towards computers

For comparison purposes, analysis calculated average overall score of attitude towards computers before the pilot study. The pilot study data revealed an average overall score of $\bar{x}=78.1\pm5.2$ - indicative of a slightly favourable view of computers, and similar to the views reported by Brodt and Stronge[109] ($\bar{x}=70.8$ (SD not reported)), Simpson and Kenrick[110] ($\bar{x}=61.3\pm1.64$) and Scarpa, Smeltzer and Jasion[111] ($\bar{x}=71.4\pm10.9$). Respondents from the pilot study may share similar overall attitudes towards computers as hospital nurses who participated in those studies.

Each of these three studies also found relationships between demographic data and *overall* attitude towards computers (sections below discuss pilot study relationship findings for individual attitude measures). The relationship between formal educational training and overall attitude towards computers found by Brodt and Stronge's[112] supports the pilot study ones. They too detected that those respondents with less formal educational training (in their case, LPNs) showed a more negative attitude towards computers compared with those with more formal education (RNs).

The findings of Simpson and Kenrick[113] support the pilot study finding that more years of work experience as a public health nurse may relate to less acceptance of computers. Brodt and Stronge[114] detected a different relationship: they found nurses with greater than 21 years of nursing experience showed more positive attitude towards computers compared with those with fewer than 10 years. The time period and technological context that researchers conducted the studies could present one plausible explanation: Brodt and Stronge[115] conducted their study in 1985 while Simpson and Kenrick[116] and the current pilot study collected data in 1994 and 2000, respectively. In the decade between the two studies a general trend emerged towards greater computer literacy in nursing schools, academic institutions and the workplace; nurses with less experience may have graduated more recently and had more exposure to the presence and benefits of computers in nursing practise.

These findings suggest facilitators of computer implementation programmes should afford particular attention to users with 11 or more years experience in Public Health Nursing and those with LPN or RN-Diploma education. Measures designed to improve the training process to assist such users appear summarised at the end of this chapter.

The pilot study analysis findings did not support the Scarpa, Smeltzer and Jasion[117] finding that previous experience with computers related to more favourable attitudes towards computers, although their low response rate may have contributed to this difference.

Study design and analytical tools used

To improve our ability to draw conclusions from the data collected, the researcher used several design and analysis strategies.

As per recommendations of Staggers[118], the study surveyed both pilot study and non-pilot study participants during both the pre-pilot and post-pilot measurements to provide data to account for other factors that might explain any change between pre-pilot and post-pilot responses.

In doing so, although the researcher intended to lower the likelihood that factors other than the pilot study could account for differences between pre- and post-pilot responses, the pilot study occurred in offices serving predominately urban areas of the health region. Some differences detected may have resulted from urban/rural differences. Although logistically complex, a study design that randomised the pilot locations of the system could offer results that better represent how the system would function throughout the health region.

The analysis matched pre- and post-pilot responses to better detect changes in an individual participant's attitudes. This permitted comparison of changes occurring between different individuals. Failing to match pre- and post- responses would have limited analysis to only correlative, group findings.

Because the small study sample limited the ability of most parametric tests (eg. Odds Ratio, Risk Ratio) to reject a null hypothesis amidst a low level of precision, analysis employed a non-parametric test to detect differences in proportion - Fisher's Exact test. Although less restricted by limitations in sample size, Fisher's Exact test carries less robustness compared with most parametric tests. Analysis *can* employ the test to identify differences in response distributions of cross-tabulated factors, but one *cannot* infer a relationship exists between those factors. This limits any conclusions drawn from Fisher's Exact test findings described in the report.

After some consideration, the analysis excluded a calculation of means since the mean statistic assumes respondents consider each successive element of a rating scale as equidistant in value to other elements. Specifically, one cannot assume respondents consider the difference between strongly disagree and somewhat disagree as equal to the difference between "neither disagree or agree" and somewhat agree[119 120]. Instead, analysis used the median statistic as an indicator of the general trend in responses.

Analysis employed a non-parametric test to determine the significance of differences in median response as a general indicator of opinion. The Wilcoxon Signed Rank test determines differences between the pre-pilot and post-pilot median responses.

Compared with its parametric equivalent, the Paired t test, the Wilcoxon Signed Rank test does not require compared groups to have similar variance and normal distribution. The test holds less power in its ability to detect significant differences between the medians of two different groups[121]; the test may not have detected some differences considered statistically significant by its parametric equivalent.

Training

Respondents rated four statements that focussed on different aspects of training. A majority of both non-pilot and pilot participants felt they did not receive sufficient training for the current computer system.

Training implementers followed several suggestions offered by Adaskin et al[122]. Designers pre-tested electronic formats in paper form with prospective users before implementation. Telephone technical support offered assistance and on-going training at all operational hours. In contrast to Adaskin et al[123] who suggested two - four hours sessions allowed sufficient time for conveying instruction, pilot study participants received 11 hours of training over three sessions.

Several factors may have contributed to user dissatisfaction with the training. The developer could have further developed the pilot system before its initial presentation to nurses during the first training session.

As suggested by McAlindon, Danz and Theodoroff[124], prospective users - public health nurses - contributed to the design of the pilot system throughout its development. From onset to the end of the pilot period, pilot system development relied on the content and design contribution of public health nurses, as recommended by Karshmer and Karshmer[125]. Minimal testing by potential users occurred before the initial training session due to time and resource constraints. Any technical problems encountered during the pilot session only contributed to the discomfort of novice computer users. Problems with the transfer of records between handheld and desktop also supported their doubts.

Comfort and experience with computers differed considerably among the 15 nurses who attended the training session. Understandably, some individual trainees struggled with the training. Although training format and materials may have contributed to their difficulties, additional mentors would have benefited the trainee learning. In contrast to the recommendations of Adaskin et al[126] to maintain separate training groups for fast and slow learners, having key colleagues formally mentor during the training could help to establish their role as technical resource people throughout the pilot study.

Trainers may not have scheduled sufficient time during training to convey the rationale and benefits of using the system to users, as suggested by Ash[127] and Nagelkerk, Ritola and Vandort[128]. Trainers did however incorporate a session covering related nursing practise expectations and the rationale behind pilot system’s design prior to the actual training sessions occurred.

Due to time constraints, developers could not create a paper-based manual for the training sessions. Nurses predominately relied on their own notes for reference after the training session until distribution of the manual.

Although trainers could show all trainees the navigation on the desktop part of the pilot system via use of a LCD projector, trainees could not view use of the handheld applications. Use of a mini camera (e.g. web-cam style device) could assist with projecting the instructor's activities on the handheld computer onto a projection screen.

As previously mentioned, a majority of respondents felt training did not occur in a timely manner. Pilot study participants expressed this dissatisfaction, despite having several weeks after the first two training sessions to practise using the PCR system before it formally replaced paper forms. The proportion of respondents who felt dissatisfied with the timing of training remained consistent before and after the pilot period, among both pilot and non-pilot participants. This suggests that either users found little difference between the pilot system training sessions and other sessions, or some respondents may have referred to all computer-related trained they received in general.

At least one pilot study participant felt dissatisfied with the pilot system training in particular; she commented:

> "[Concerning] the palm-pilot: not enough preparation and time before mandatory... not enough time to practise using handheld and computer"

Future implementers will need further consultation with staff to determine how training design can assist the timely preparation of users.

Cost

A majority of respondents felt the situation where only one person at a time could use a computer inhibited staff efficiency. This finding remained consistent before and after the pilot period, among both non-pilot and pilot study participants. As more tasks require PHNs to use computers in the future, public health managers will need to consider the ratio of staff to computers to ensure the success of future attempts to implement computer information systems.

Respondents generally, however, neither disagreed nor agreed that computers would lead to increased nursing workload costs. No majority of respondents felt certain of whether computers would result in decreased time costs. Analysis found this consistent among both non-pilot and pilot study participants. As suggested by the wide range of times reported by pilot study participants (from 15 minutes to six hours), users may require more experience before they can better assess these costs.

Communications

Responses to the communication statement suggests the impact of computers on inter-agency communications has not become apparent in the work of public health nurses. Impact on such communications requires further integration of computer-based technology such as e-mail in the activities of both public health nurses and other agencies, although the need to protect client confidentiality may limit the role of Internet-based computer applications in inter-agency communications.

Perceived benefit of computers

Responses to all statements intended to measure the perceived benefit of computers suggest a majority of PHNs did not feel convinced of a positive benefit to computers. For each statement suggesting a positive benefit of computers, a majority of respondents either disagreed or "neither disagreed nor agreed" with the statement. For negative statements concerning the benefits of computers, no majority of respondents agreed or disagreed. This appeared consistent among non-pilot and pilot participants. This finding contrasts those of Murphy, Maynard and Morgan[129] who found their respondents most commonly said use of their computer system results in too much time away from patient care. Their study also did not detect demographic characteristics related to attitude, although their post-test sample had completed a three year training period. The views of members of the cohort may have had greater opportunity to become unified after such a long training period.

During the pilot study, respondents recorded the time required for charting. Charting time ranged between 15 - 360 minutes depending on the amount of technical difficulty. Users felt frustrated with the system at times when technical difficulties arose.

Pilot study participants decreased their acceptance of client chart accuracy; this may have arisen from key-in errors generated while using the pilot system. With greater experience and practise using the pilot system, this perception may change. Pilot study participants may also have become more aware of client chart inaccuracies, the implementation process placed a greater emphasis on information management during pilot system implementation.

Despite extensive promotion of full time technical assistance during the pilot study, on at least several occasions users delayed or did not at all request for technical assistance. This may have arisen from fear of embarrassment, the determination to resolve the problem themselves or a preference for getting advice from colleagues. Relating to the helpfulness of colleagues as technical resources, one pilot study participant remarked:

> "Just asking the nursing staff questions as you come across a problem on the computer is an education in itself."

Regardless of the reason, difficulties using computers probably did not encourage nurses to perceive the positive benefits of computers to them.

Brodt and Stronge[130] emphasise the importance of attitude as it is "antecedent to behaviour". Positive attitude toward a behaviour promotes its acquisition. Future computer system/applications implementation strategies should promote the positive benefits of the system or application for the user and client.

Privacy

A number of measures helped to ensure that client information entered into the system remained confidential and at least as secure as information written on paper formats (please refer to Section 2.2 Ethical issues and confidentiality). Despite these measures, analysis uncovered no differences between non-pilot and pilot study participant responses to statements that suggested computers threaten the privacy of clients. Future implementation strategies should better promote measures taken to ensure client confidentiality.

Law

A majority of respondents did not feel computers would result in more lawsuits for nurses.

Receptiveness to integration of computers

Five statements measured the receptiveness of respondents to the integration of computers into the nursing workplace. Responses to such statements suggest a majority of respondents - both non-pilot and pilot participants, before and after system piloting - appeared receptive to the integration of computers..

Following the recommendations of Adaskin et al[131], implementers introduced several measures to assist the integration of computers. Designers pre-tested electronic formats in paper form with prospective users before implementation. For the duration of the pilot study, telephone technical support offered assistance and on-going training at all operational hours. To facilitate communication of problems and issues to implementers and management, users submitted a one page form each week describing the number of clients entered into the system, technical problems encountered and overall impressions of the system. Management scheduled additional staff to distribute the workload of pilot system users.

Despite these measures, at least one nurse’s comments showed conditional receptiveness:

> "Computers are a great benefit to nurses but I believe we need more support and training to have them considered an asset and a time saver."

Groups requiring additional attention

Analysis found differences in the proportion of negative responses from respondents with certain characteristics. Some respondent groups may have a lower likelihood of possessing positive attitudes towards computers. For various statements, a disproportionate amount of nurses who had less experience with computers, older, not recent degree recipients, with less formal education and without home computers responded less favourably to different statements describing aspects of computer integration. Implementers of future computer systems or applications need to develop strategies that can better assist these groups in their training.

3.7 Conclusion and Recommendations

The researcher gathered post-pilot responses to the attitudinal questionnaire while users possessed only a three month exposure to the pilot system, and fewer than a six month exposure to Web board and e-mail applications. Despite this, several conclusions drawn from their responses can assist future implementers.

Pilot study analysis found average overall attitude towards computers similar to those found in other studies. Results support Brodt and Stronge's finding that formal educational training may influence overall attitude towards computers, and Simpson and Kendrick's identification of number of years of work experience as an influential factor. Previous experience with computers did not influence overall attitudinal scores, although analysis determined that the factor may influence particular attitudinal measures.

Implementing the pilot system in randomly selected sites may help to control for differences between urban and rural offices. Doing so may yield results more representative of the integration of the system throughout the health region.

All respondents felt they did not receive sufficient training for the current computer system. Factors that may have contributed to this view include: inadequate testing of the pilot system before training sessions and implementation period; the absence of a formal peer mentor mechanism to assist slower learners; and distribution of a manual for the pilot system occurred weeks after training events. Respondents also felt training did not occur in a timely manner.

Public health managers will need to consider the ratio of computers to staff in future implementation of computer information systems.

Users perceive the current computer systems has little benefit to inter-agency communications, despite implementation of email and the Web board. The organisation should further promote the use of these technologies to the benefit of inter-agency communications.

Implementers should better promote security features of the pilot system designed to protect client confidentiality.

A majority of both pilot and non-pilot respondents appeared receptive to the integration of computers. Nurses with less experience with computers, older, not recent degree recipients, with less formal education and without home computers responded less favourably to aspects of computer integration; future implementers should develop strategies to better assist these groups in their training.

This measure of user attitude contributes to a better understanding of third stage technological assessment issues[132] - the impact of implementing the technology on the work environment and practise. The nurses exhibited less favourable attitudes towards training and perceived benefit of computers statements, again suggesting greater emphasis on ensuring trial-ability and observability, as postulated by Diffusion of Innovation theorists[133]. From a marketing approach[134], peer-to-peer instruction could improve training uptake via a more appropriate source, channel, message and setting. Future implementation should allot sufficient time for development and system pre-testing, and for training and practise of the system before full integration into daily work.

Recommendations

Consideration of the analysis and existing literature resulted in the following recommendations:

- Post-pilot period responses taken June 2000 suggest changes to the approach and organisation of training for both pilot and non-pilot study participants.

The experience of both trainees and the developer/trainer suggests the following recommendations:

- Include a formal testing of applications by potential users before the training session. One or two nurses more comfortable with computers could assist with beta-testing.
- With greater familiarity with the pilot system, nurses involved with beta-testing could act as mentors during the training sessions.
- Develop a full paper-based manual or a brief, quick-reference sheet for the training sessions.
- Pertaining to handheld computer training, use a mini camera/ video camera to capture activities with the handheld computer for trainees to view.
- Consult with staff before implementing future computer systems to determine how training can adequately prepare users in a timely manner.
- Consider the ratio of staff to computers before requiring nurses to complete more tasks on the existing number and organisation of computers in each office.
- In future implementation strategies, promote awareness of both the measures taken to ensure client confidentiality and the positive benefits of new computer applications/systems for users and clients.
- Before introducing future computer applications or systems, consider the views of users defined by the following characteristics: experience with computers, age, educational background, year most recent degree was received and possession of a home computer (please refer to the results and discussion section for further details).

Chapter 4: Does PCR data quality measure up with data from other sources?

4.1 Comparison with findings of an in-house chart audit

The study compared several characteristics of data collected using the pilot system with the results of an in-house perinatal chart audit[135]. This comparison served as an indirect measure of any changes in the completeness of information collected for public health client records.

The analysis drew estimates of paper form data completeness from a peer audit of perinatal charts for infants born between December 1, 1998 - February 28, 1999. The Peer Audit Summary Report[136] described twelve characteristics/data elements of client's perinatal charts. Inspection of the comparability of the data elements led to the determination that comparison of data completeness could only utilise four chart audit data elements: infant's date of birth, date of discharge (mother and baby), date referral received by PHN and date of telephone assessment/home visit.

The study did not compare the remaining eight characteristics/data elements for a variety of reasons:

- question differences between the two systems;
- differences in design or organisation of the two systems
- differences in when (e.g. prenatal vs. early post-partum) or how (e.g. paper-based system used a self-administered questionnaire to collect some data) a

characteristic/data element was collected

- collection of the data element from mothers on the paper-based system occurred via a self-administered questionnaire
- unclear assessment criteria used to collect the characteristic/data element

Table 2 lists all characteristics/data elements presented in the Peer Audit Summary Report[137], the data elements used in the comparison of completeness and the specific reason for the exclusion of some data elements in the comparison.

4.1.1 Methods

Following identification of comparable characteristics/data elements in the Peer Audit Summary Report[138], analysis of the data elements identified data elements in the pilot system database equivalent to those identified in the paper-based chart audit report. For each comparable data element, the analysis calculated the proportion of records completed, and compared it with the proportion detailed in the Peer Audit Summary Report[139]. Significance testing employed uncorrected Chi-square test for proportions.

4.1.2 Results

Three of four data elements showed a relatively high proportion of records completed in both the paper-based and pilot study systems: infant's date of birth (339/344 (99%), 107/107 (100%), respectively), mother and infant discharge date (322/344 (94%), 95/107 (89%)) and date of telephone assessment / home visit (326/344 (95%), 103/107 (96%)). Chi-square test for proportions indicated no significant differences between the two systems in proportion completed for the three data elements.

Comparison of the data element for date PHN received the referral detected a significant difference. A higher proportion of pilot database records contained the date PHN received the referral, compared with paper form records (98/107 (92%) compared with 182/344 (53%)). Chance cannot easily account for this difference (Chi-square test for proportions p-value < 0.000001). For a tabular summary of the results, please refer to Table 3.

4.1.3 Limitations

Several limitations restrict conclusion drawn from the findings of this comparison. The researcher extracted the proportion of completed data elements described for the paper format from findings of the Public Health Services' Peer Audit Summary Report[140]. The report discloses minimal description of methodology and no information on design measures implemented to minimise inter-observer bias or other forms of systematic error.

Three public health offices in the Industrial Cape Breton region participated in data collection using the pilot system. In contrast all public health nurses from the region’s 15 offices probably participated in the audit of paper-based charts described in the Peer Audit Summary Report[141]. The exclusion of electronic charts from non-pilot study offices may have contributed to differences found between the two systems.

Considerable differences also exist between the original paper form and the electronic forms used in the pilot study. Changes in the appearance and content of the pilot study format may account for the difference detected in the single data element. Hawthorne effect might also have played a role: aware of the pilot study evaluation, nurses may have felt encouraged to excel in their tasks.

The need to protect Public Health client confidentiality primarily governed the decision to use the findings of the Public Health Services' Peer Audit Summary Report (for more information, please refer to Section 4.1.4 Discussion). Hence, comparison could only occur using data elements selected during the peer audit process. Large differences in the pilot study forms' content precluded the use of a number of peer chart audit data elements.

Based on these findings, the researcher does not advise drawing conclusions about data validity or other biases possibly related to pilot system use. Clients, for example, may have felt less comfortable revealing information for entry into a computer. Users may have misinterpreted the meaning of a response option and subsequently coded a response incorrectly.

In conclusion, although the use of past chart audit findings permitted a small comparison between the completeness of data captured by paper and electronic formats, differences in structure and content limited the number of comparable data elements in the two systems.

4.1.4 Discussion

Ideally, in-house paper-based and pilot system records for the same clients could be audited and compared for completeness. Because public health practise did not permit researchers to view client records directly for confidentiality reasons, only the organisation's public health nurses could review existing charts. Due to time and resource constraints the researcher could not assemble a team of nurses to assess past client charts for more comparable data elements. Differences between the design, organisation and questions of the existing paper-based and pilot systems would have further limited the extensiveness and detail of such a comparison.

As noted above, a number of changes to the content of the pilot study system forms resulted in considerable differences between it and the existing paper-based system. As a result, researchers could compare few data elements with the findings of the previous chart audit.

Records showed three of four data elements had similar proportions of completeness. An already high level of completeness of paper-based records probably contributed to the lack of apparent difference between records from the two systems. All three data elements measured over 90% completed in paper format records. Greater user familiarity and comfort with the new structure, content and electronic-medium of the format may result in future improvements.

Analysis detected a significantly greater proportion completed in only one data element - the date PHN received the referral. Analysis has not identified a clear explanation for this difference: the data element did not require a mandatory response; perhaps its novel presentation on a computer screen helped to remind PHNs to document the information.

Although marked improvements in data completeness stands as a clear benefit of computerised client information systems, a better understanding of differences in data quality and completeness requires a more complete and detailed comparison of paper and electronic data elements. Researcher could only compare four data elements for differences; a greater number of data elements would contribute to a more comprehensive understanding of differences between the two systems. Improved understanding of the relative performance of the two systems requires comparison of each of the system's sensitivities with a gold standard, such as the RCP data.

Unfortunately, the RCP data provided did not permit comparison with in-house paper data.

4.1.5 Conclusion and recommendations

Due to a low number of measures and other limitations, the study could not generate conclusive findings or recommendations towards improving data completeness. For a fruitful comparison of in-house paper records and electronic format, researchers should establish common data elements of comparison and elucidate methods for auditing both paper and electronic charts *before* beginning data collection.

4.2 Comparison with data from an existing hospital-based system

Determination of a good perinatal information system resides in not only the utility of the system for public health nurses, managers and clients but the quality of data it produces. To measure this, the researcher compared information collected by the pilot system with data from a well-recognised and respected provincial hospital-based perinatal data warehouse, the Reproductive Care Program of Nova Scotia (RCP).

This section describes the analytical comparison of data from the two systems.

4.2.1 Methods

Analysis compared data collected by the pilot information system (the ENS pilot data set) with records captured in the Atlee database of the Reproductive Care Program of Nova Scotia (RCP). Researchers agreed on a comparison of 100 cases: public health nurses first collected data on 100 cases between 2 March - 4 June 2000 in the participating offices.

The process of requesting and acquiring the relevant hospital data began with approval of a joint request by the Reproductive Care Program of Nova Scotia and Eastern Region Public Health Services to the Cape Breton Healthcare Complex.

Public Health Services obtained the actual RCP Atlee data set by a request for all infants born between March 2 - June 4, 2000. Public health requested a small subset of

Atlee database variables - those relevant to public health. This data set included infants born at the Cape Breton Healthcare Complex hospitals (deliveries occurring at hospitals in Glace Bay, Sydney, North Sydney and New Waterford).

The analysis compared common variables in the two data sets by: frequency among unmatched records, frequency among matched records and estimation of data quality.

Analysis re-coded data elements whose variable name or coding scheme differed in the two data sets to new variables using a programming macro. The nurse manager also reviewed the recoding strategy to ensure the correct re-coding of data elements. For specific details on recoding, please refer to Annex 10: Comparison with hospital-based system - analysis macros.

Frequencies of unmatched records

Following re-coding, determination of data element frequencies occurred with comparable elements in both data sets. Analysis noted the proportion of missing data for each variable in each data set. This initial analysis *did not link* records for the same infant found in the two databases (refer to as “unmatched”).

Frequencies of matched records

A second analysis linked together data sets of the pilot system and RCP infant records by maternal health card number. This process assess matched records for: number of records completed; proportion of records with the same data in both ENS 3 pilot and RCP Atlee data sets; response frequencies among only matched records; and significant differences in the detection of risk factors relevant to public health post-partum followup.

Estimation of data quality

The researcher conducted an overall comparison of the information systems, generating an overall score of data completeness among only those infants with linkable records in the two data sets. For each matched data element, analysis calculated the proportion of records with a completed response, assessing missing data, no data, blank and don't know codes as incomplete. For each information system, the sum of all such scores determined the database's overall score of data completeness. Figure 38 shows the equation used for this calculation.

Calculations of pilot information system sensitivity employed RCP Atlee data as the "Gold Standard". According to Rothman, the "sensitivity of an exposure measurement method is the probability that someone who is truly exposed will be classified as exposed by the method"[142]. For the pilot information system, the estimation of sensitivity calculated the probability an infant who measured positive for a condition by the RCP system, also measured positive by the pilot system (Sensitivity = a/(a+b))[143].

4.2.2 Results

Comparison of frequencies using the records held in the Atlee and ENS pilot data sets

Public health Services requested some 63 variables from the Reproductive Care Program of Nova Scotia. Of the hundreds of perinatal variables contained in the Atlee data set, the comparison determined these 63 variables as relevance to post-partum public health followup.

Of the RCP data set, 47 pilot variables collected information similar to the 63 Atlee variables, although further assessment found only 36 variables suitable for comparison. Reasons for not comparing the remaining variables included: slight differences in the actual information collected by the two information systems; systematic data collection errors (e.g. smoking before and during pregnancy) and administrative data content (e.g. names of mother and infant).

RCP contributed a data set with records for 182 births while the ENS 3 pilot data set included 124 births (fewer in some data sets) for the three month period. As a result of this disparity, analysis found differences between the two data sets in the frequencies of nearly all variables. For a complete table of frequencies for unmatched records, please refer to Annex 11: Comparison of unmatched records held in the Atlee and pilot study data sets.

Comparison of matched records using related records held in the Atlee and ENS pilot data sets

Analysis matched records in the Atlee and ENS pilot data sets using the mother's health card number, comparing 36 pilot study variables in total. Only 63% (115/182) records in the two data sets matched. Analysis for characteristics to generate a profile of the clients with incomplete data sets yielded no conclusive findings.

The comparison detected significant differences in the proportion of records completed for 17/36 variables. The pilot study data set contained fewer completed records in 14/17 variables, with differences ranging from 4% to 40% ($\bar{x}$=17%). Only for three data elements - maternal occupation, vaginal birth after previous c-section and forceps use - did the pilot data set contain significantly more completed records ($\bar{x}$ difference = 51%, range 27%-78%). For details, please refer to Annex 12: Comparison of matched records using related records held in the Atlee and pilot study data sets.

Estimation of data quality

Data completeness

Using data from 115 records, the estimation of data quality considered 23 of the 36 comparable data elements; the remaining 13 data elements excluded from this comparison contained mostly administrative data. Because some data elements captured information pertaining to a subset of the population (for example, number of births using forceps documents only those mothers who had vaginal births), the calculations for the proportion completed for some data elements involves fewer than 115 responses. The researcher removed from the comparison three data elements found to have coding discrepancies, whereby response codes found in the data element did not reflect those described in the coding manual. Table 4 details the total number of records compared for each data element.

Analysis of data completeness determined that Atlee data elements averaged 88% (Range 0.15-1.00, n=21) complete, while the pilot data elements averaged 84% ($\bar{x}$=0.84, Range 0.44-1.00, n=20). Comparison of a calculated data completeness summary score - the total observed divided by total expected - revealed significantly higher proportions of completed records in the Atlee database (89% (1967/2197)), compared with the pilot database (84% (1758/2086)). Chi-square test for proportions suggest chance cannot easily explain this difference (χ^2=26.08, $p<0.000001$).

Sensitivity score

Sensitivity score calculations for the pilot system referenced data collected by the RCP system as the ‘gold standard’ for 20 of the 23 comparable data elements; analysis assessed response coding errors in the remaining two data elements. Annex 13 contains a series of tables showing the sensitivity score calculations for all 20 data elements.

For the pilot system, calculations determined an average sensitivity score of 0.83 ($\bar{x}$=0.83, Range 0.53-1.00, n=19). That is, on average the pilot system detected a condition documented by the RCP information system 83 times out of 100. Table 4 offers a summary of the sensitivity and data completeness scores.

4.2.3 Limitations

For frequencies calculated for matched records and estimates of data quality, results represent only those records successfully matched in the two data sets.

The analysis calculated sensitivity scores for the pilot system relative to the RCP information system. This comparison assumed the reference system (RCP system) holds the correct data during assessment of any discordances between the pilot and Atlee data sets.

4.2.4 Discussion

Although data quality presents a critical measure of the pilot system's effectiveness under 'routine' conditions, assessment of the health technology itself must distinguish errors in data quality arising from its capture by the system, from assessment and data collection errors.

An inquiry into in-house, grey literature identified no prior data comparisons of this type. Sensitivity analysis applies calculations described by Rothman[144].

Differences in number of infant records

As mentioned in the Results section, the pilot system collected information for only 124 clients, compared with the 182 records collected in the same time period by the RCP system. Even fewer records matched (115/182).

Analysis offers several explanations for 35/67 of the missing records. First, the pilot study data set excluded mothers who gave birth at a Cape Breton Healthcare Complex hospital but lived outside the service catchment of pilot study offices (for example, Sydney Mines and Northside). Although the comparison attempted to restrict the Atlee data set to mothers with service catchment municipality codes, several more general codes like "Cape Breton Municipality" permitted the inclusion of mothers living outside the service catchment. The group of mothers with the “Cape Breton Municipality” code who   The Atlee data set designated 32/67 unmatched records as living in “Cape Breton Municipality”, despite having delivered their baby at hospitals in the pilot office service catchment.

Second, since the Atlee data set contains records of births at only Cape Breton Healthcare Complex hospitals (please see Methods section), the Atlee data set excluded three mothers who lived in the service catchment of pilot study offices but gave birth in other hospitals (e.g. IWK Grace, Halifax).

Analysis could not determine a clear explanation for why the remaining 32/67 clients did not have records in the pilot data set. Although insufficient data restricts assessment of plausibility, several possible explanations for the absence of client records include: (1) the PHN assessed the client as healthy and did not require further care; (2) the client refused assessment and further contact; (3) despite having developed a good discharge referral system with the hospital, PHNs may not have received a discharge referral form from the hospital for some mothers; (4) circumstances may have allowed a public health office to receive the assessment but not refer it to a PHN in the appropriate office for follow up.

When the comparison attempted to match Atlee and pilot study data set records, the researcher could not match six records (delivered at the Cape Breton Regional and Glace Bay hospitals) found in the pilot study data set but not in the Atlee data set. This may have occurred for the previously mentioned reasons, or via entry of different health card numbers for the same client in each database. Mis-entry of the health card number or a change in the health card between admission to hospital and public health followup may have resulted in the failure to match.

Comparison of frequencies

The two information systems coded a majority of data elements (26/36) differently. For delivery hospital, marital status, episiotomy given, infant's sex, comparison required a simple recoding. Several data elements required response code aggregation for comparability with equivalent variables in other data set (for example, responses to the pilot system's number of prenatal classes variable aggregated to simply attendance of prenatal classes (Y/N)). Some of Atlee's clinical data elements required dis-aggregation for comparability: for example, the Atlee database variable "method of delivery" contained information for three pilot system variables - breech, forceps and vacuum. Others such as pre-pregnancy smoking, smoking during pregnancy and alcohol consumption needed response code aggregation of both the Atlee and pilot system data elements.

Estimation of data quality

The researcher employed sensitivity analysis in calculating an estimate of the overall data quality of the pilot information system. The sensitivity of an exposure measurement method is the probability “someone who is truly exposed will be classified as exposed by the method.”[145] Effective public health perinatal screening relies on a perinatal system with a high sensitivity score; it allows mothers who *may* have an undesired condition/exposure to be “red-flagged” for further followup.

Although the researcher found identification of the undesired condition straight forward for most data elements (for example, five minute APGAR scores with low values), no clear condition emerged as undesired for several data elements (for example, how labour initiated and infant’s sex). In such cases, the analysis drew an arbitrary selection.

Is the pilot system sensitive enough or not? Based on 20 data elements, analysis calculated an average sensitivity score of 0.83. Insight into how such a sensitivity score translates to the effective detection in perinatal screening led to a comparison of the proportion of ‘potential risk’ characteristics among the compared data elements. These included: single, employed (mother), first pregnancy, no previous c-section, smoker, alcohol consumer, did not receive prenatal education, received an episiotomy, low birth weight, pre-term, low APGAR scores, admission to neonatal intensive care unit.

Analysis found differences in the proportion of ‘potential risk’ characteristics detected in five data elements. The RCP system recorded a higher proportion of: single mothers (44/93 vs. 30/93, $\chi^2=4.4$, $p=0.036$), mothers who smoked during pregnancy (36%(39/110) vs. 24%(26/110), $\chi^2=4.24$, $p=0.039$), mothers living outside urban centres in the Industrial Cape Breton Municipality (30%(33/110) vs. 11%(12/110), $\chi^2=12.32$, $p=0.00045$) and infants admitted to the Neonatal Intensive Care Unit (23%(25/111) vs. 13% (15/111), $\chi^2=4.39$, $p=0.036$). The pilot system recorded a higher proportion of the maternal employment data element (0% vs. 40/88, $\chi^2=43.7$, $p<0.00001$).

Although the frequency of the characteristics in question influence what this approach detects, it does serve to illustrate what can the pilot system can miss. Viewing Atlee data as the ‘gold standard’ and pilot study data reflect the quality that it would typically capture and despite having an average sensitivity score of 0.83, public health could potentially stand to miss the identification of 15 per 100 single mothers, 11 per 100 mothers who smoked during pregnancy, 19 per 100 mothers living outside urban centres in the municipality and nine per 100 infants admitted to the Neonatal Intensive Care Unit!

Public Health Services is recognised as a first-rate, accredited institution and one would expect that other mechanisms not reflected in the pilot system data (e.g. informal referrals, undocumented visits) served to meet the gaps identified. Pilot system users may have failed to enter information correctly into the system, or to reflect updates of client record information in the system as they normally would on paper charts.

To improve the pilot system sensitivity score, pilot users require further training in collection and recording of data specifically for the pilot system. The researcher anticipates that review and clarification of data entry expectations, such as clarification of if a mother's parity should include the current delivery, will also help to improve system sensitivity.

4.2.5 Conclusions and recommendations

Opportunity for improvement of data quality

For future data sharing practises between RCP and Public Health to have mutual benefit, piloted data collection and entry practises require some improvement. For the pilot period, data quality comparison noted fewer infant records and a lower proportion of completed responses in the pilot data set.

Sensitivity analysis of pilot system data assessed an average score of 0.83. Taken together with a comparison of how well the two systems identified 'potential risk characteristics' with Atlee data as the gold standard, the score suggests considerable opportunity exists for improving the pilot system's potential for screening mothers requiring public health follow up. With additional training and clarification of assessment and data entry expectations, the pilot system can attain data quality comparable to the

RCP system.

Complementary data offer

The value for public health of having information from both the Atlee and pilot systems emerged through the review of meta-data available for both system databases. In addition to a wealth of clinical information, the Atlee database collects information on past pregnancies that could assist public health nurses in post-partum assessment and care. Information on the mother's past history - previous miscarriages, previous low birth weight babies - could help public health nurses to determine postpartum client needs so they can best address them.

The pilot system's in-depth information on post-partum care and followup could offer hospital clinicians greater understanding of effective and long-term benefits of their therapeutic interventions.

Recommendations

This assessment suggests implementation of the following recommendations:

- public health review practise guidelines for early post-partum identification and referral to ensure documented contact with *all* mothers.
- Public health commit additional training towards the review and clarification of public health practise expectations for assessing and entering data elements.
- Following implementation of the above recommendations, conduct a similar data comparison to determine if data quality has improved.

Chapter 5: Costs compared with potential savings of the PCR system

The study performed a cost analysis to assess the differences between the existing paper-based system and the pilot information system. Difficulties in capturing impact data for either system on perinatal health prevented the completion of a full economic evaluation[146]. Presentation of findings in this chapter offer some understanding of the relative costs encountered during integration of the pilot system in Eastern Nova Scotia. Readers should not generalise findings to other contexts.

5.1 Methods

The implementation costs of the pilot study serve as the basis for this estimate of the projected costs and potential savings of a complete integration of the piloted electronic data capture system. Although the pilot study involved only a proportion of the Eastern Region's public health nurses, estimates consider all 37 PHNs per annum with each public health nurse assigned a handheld computer.

Calculations of cost and potential saving items displayed in the results column draw from estimates of cost differences found between the pilot system and a comparable item in the existing paper format system. The comparison categorised *costs* as items where the net difference resulted in a loss of revenue, and *potential savings* as items where the net difference resulted in a gain of revenue.

Per annum estimates of non-recurrent costs calculated the total cost of each budget item using straight-line depreciation over five years.

The analysis based salary related costs on the average hourly rates ($25/hour) at the time of the study for clinical care nursing work found on a national job posting website[147]. The researcher could not obtain national statistics for average hourly rates specific to public health nurses.

This assessment did not include the annual cost of desktop computer equipment since public health purchased the equipment prior to the pilot study, and intended its use by both public health nurses and administrative staff for several other purposes. Based on current computer equipment prices, the researcher anticipates an annual cost of $7,160 for 30 - 800 Mhz Pentium Celeron Desktop computers (straight-line depreciation over five years).

Detailed cost calculations

The following points describe the specific calculation of costs. Table 5 offers a description of points, referenced by letter designated for each point.

a. Training of public health nurse in use of PCR system - Cost based on 10 hours of initial training required for each of 37 public health nurses @ $25/hour. Costs distributed over the system's estimated operational lifespan of five years ((10hours x 37 PHNs) x

$25/hour = $9,250.00/5).

b. Handheld PCs with required cables and accessories - Per unit cost of handheld PC based on purchase price of Compaq Aero 1500 handheld PC with straight-line depreciation over five years ($500 x 37 of units = $18,500.00/5).

c. Handheld software - Software unit price with straight-line depreciation over five years ($492.00/5).

d. Cost associated with generating future perinatal statistics produced in previous years (calculations) - Potential savings calculated by comparing estimated cost of generating past perinatal statistics with cost of generating perinatal statistics via Electronic Data Capture process (($2775.00 + $180.00) - ($62.50 + $48.00)).

e. Estimated cost of generating past perinatal statistics - Conservative cost estimates for past perinatal statistics based on: time required for each PHN to draw, review, tally counts for each client (3hours x $25/hour x 37 PHNs = $2775.00); time required for regional administrative assistant to query PHNs (3hours), collect data, data entry and tallying (12 hours) (15 hours x $12/hour=$180.00).

f. Estimated cost of generating perinatal statistics via Electronic data capture system - Cost estimates for Electronic Data Capture process for generating perinatal statistics based on: time required for one PHN/office to export non-nominal datafile to disk and mail (10minutes x $25/hour x 15offices = $62.50); time required for administrative assistant to query PHNs (3 hours), aggregate data sets (1 hour) and run pre-programmed macro (negligible) (4 hours x $12/hour = $48.00).

g. Cost of handheld screens' protective sheets - Administrative assistant hand cuts protective sheets from acetate sheets. Estimated cost includes labour.

h. Cost savings attributable to time required to complete original paper forms compared with time required to complete electronic forms - Time required to complete original paper forms (#201, 202, 203) based on estimates provided in the LoPHID Eastern Nova Scotia Information Management Case Study, 1998 (55 minutes). To account for charting time costs that may have arisen during the initial period of learning and the integration process, researchers used the mean time required to complete the electronic forms for the final month of system piloting ($\bar{x}$=53 minutes, Range: 20 - 180 minutes, n=27) ((55 - 53 minutes)/60 x 1800 births/year x $25/hour).

5.2 Results

Table 5 presents estimates of the costs and potential savings associated with implementing the PCR pilot system compared with the existing paper form system. Non-recurrent costs include the initial training and system hardware and software costs. Recurrent costs involved those associated with software upgrades and replacement protective sheets. Calculations estimate a total cost of $5758.40 per annum for the PCR system.

Quantifiable savings include those associated with generating the same type of perinatal statistics produced in previous years, reducing printer/paper costs and time costs required to complete forms. Non-quantifiable savings include greater legibility and capacity to utilise client data for targeting and planning. Use of the PCR system could result in total estimated savings of $4668.50 per annum, compared with the existing paper format system.

Estimates suggest that implementation of PCR system compared with the existing system would result in a net loss of $1089.90 per annum. This estimate does not account for costs and potential savings not easily quantifiable.

Limitations

Several factors limit the conclusions drawn from these estimates. The analysis based estimates on a projection of savings realisable with the complete integration of the PCR system.

Estimates of potential savings compare the completion of Forms #201, 202, 203 with the electronic formats of the PCR system. The paper and electronic forms differ in structure and content since the design of the PCR system forms specifies greater detail than the original paper forms. Readers should not draw conclusions about the costs/potential savings of converting a paper format to an electronic format, but of using the PCR system compared with the existing paper format.

The comparison based cost and potential saving estimates on August 2001 prices for hardware, software and labour. Changes to prices may require future re-estimation of overall costs.

Calculations established annual non-recurrent costs such as capital expenditures and training employed using straight-line depreciation. Straight-line depreciation assumes capital expenditures depreciate at a uniform rate from the time of purchase and require replacement after X number of years. Depreciation estimates do not account for changes in equipment value associated with accidental loss or damage or value changes associated with changing market trends. Training cost estimates do not account for staff turnover or productivity lost from illness or competing work obligations.

5.4 Discussion

Although calculations suggest a net loss from implementing the PCR system compared with the existing paper format system, further conclusions must account for several additional factors.

Calculations generate estimates based on a complete integration of the PCR system. The pilot study did not achieve a complete integration of the PCR system since users printed out paper copies of all client records. Implementation of the pilot system has not yet realised the potential savings of reducing printer/paper costs ($324.00).

Training in the use of the PCR system may have played a role in average time required to complete client charts. Each PHN completed forms for between five and thirteen newborns ($\bar{x}$=8). While learning to use the new forms and system, nurses generally required more time to complete charts during the initial months of the pilot study. Researchers calculated time costs based on the mean time required to complete the electronic forms during the final month of pilot system use (see Section 5.2: Results).

Also, considerable differences exist between the structure and content of the original paper formats (Form #201, 202, 203) and electronic formats of the PCR system. Additional sections on demographics, psycho-social status and the prenatal period contributed to a better understanding of the mother and infant's condition. This greater detail also made the PCR forms considerably longer than original paper formats.

Cost estimates do not account for on-going technical difficulties. Analysis cannot easily quantify the costs associated with computer crashes and data entry errors; costs can result not only from time lost rectifying the situation but also those associated with increased workplace stress.

The non-recurrent hardware and software costs will likely decrease with future technological developments. This trend could reduce the cost of future hardware and software purchases considerably.

Greater costs associated with future format changes (eg. addition of data elements) could result in more costs per annum should public health not retain 'in-house' personnel trained to make such changes. When compared with costs related to replacing paper forms of the old format with new ones, such changes could occur quickly and easily with the PCR system. Each format change must however consider database coding and integrity.

Rising cost of labour may influence the relative cost of the PCR system to the existing paper-based system. Based on a PHN salary of $20/hr (calculations not included), the net annual cost of the PCR system calculate to approximately $1500 more than the paper-based system. The calculations presented in this report, based on the current salary of $25/hr suggest a net cost of approximately $1100 more than the paper-based system (see Table 5).

The impact of improved data quality and data content propose further potential savings for information management costs. Improved legibility and data entry controls may reduce time costs associated with clarifying missing or illegible entries in a paper format or the errors resulting from mis-interpreting a written entry.

Evidence-based planning

Potential costs and savings directly related to the operation of an electronic data capture system - those discussed thus far - range in the order of thousands of dollars. The long-term impacts of evidence-based regional health planning could amount to cost savings to the health care system in the order of hundreds of thousands to millions of dollars. Potential long-term impacts range from better organised staff distribution to reduce travel costs, to the quantification of aspects of system leakage to improve staff efficiency, to improving public health programmes that result in improved health outcomes for mothers and infants in Eastern Nova Scotia. An electronic data capture system instantaneously makes available information needed for such planning. In the context of Eastern Nova Scotia's rapidly changing population, current, accurate health information is not only a premium benefit, but a necessity.

5.5 Conclusions and recommendations

Analysis of quantifiable costs and potential savings suggests an annual loss of one thousand dollars. While not easily quantifiable costs and potential savings may serve to shift costs and potential saving in the order of thousands of dollars, the impact of current, accurate health information for evidence-based planning offers potential savings through better organisational planning and improved health outcomes in the order of hundreds of thousands of dollars.

Overall, cost analysis favours the implementation of an electronic data capture system in Eastern Nova Scotia.

Chapter 6: Practical tool or executive toy? Overall conclusions of the pilot study

Limitations

In addition to the limitations presented in each of the chapters, readers must consider findings of this study in the context of several overall limitations. First, conclusions emerging from assessment of pilot system implementation generalise to only Eastern Nova Scotia public health services.

Second, some data such as cost and attitudinal data sampled at the time of the pilot may change over time and require re-assessment at a later date to confirm findings still hold. Given current trends, hardware costs - for handheld and desktop computers - may continue to decrease over time, while labour costs - for administrative and nursing support - will likely experience increases. Findings of this attitudinal questionnaire suggest changes to measured attitude towards computers may result from the replacement of retiring public health nurses with less experienced, recently graduated nurses.

Conclusions

Since the pilot study, various organisations have developed handheld computer forms using the same handheld software (Syware Visual CE) for a wide variety of enterprise applications, including: recording public housing inspections conducted by the Miami Dade County Housing Agency[148], quality assurance reporting at Haagen-Dazs production lines[149], utility metre readings at the San Francisco International Airport[150], accessing information for medical referrals[151] and hospital trauma patient records[152].

The movement to integrate computer technology into daily operational practises has clearly revolutionised information management in both public and private sectors globally. With respect to information management itself, electronic data storage offers the potential for rapid, universal access to client records from any public health office in Eastern Nova Scotia, reductions in information storage space requirements and the opportunity for inter-agency collaboration. With other health authorities following the trend to convert to electronic client records, responsive provincial and federal requirements may eventually require regional health authorities to comply with the trend.

Practical tool

The handheld computer is an appropriate technology for the routine recording of public health nursing's perinatal client information. This pilot study demonstrated that non-programmers can develop an ethically-sound application for collecting perinatal client information electronically - permitting analysis of otherwise under-utilised data.

This study found pilot system data elements reflected an average sensitivity score of 0.83 when compared with those of a well-established, provincial, hospital-based perinatal information system. Assessment of differences found in the proportion of ‘probable risk’ characteristics, and significant differences in data completeness between the two systems further confirm that use of the pilot system requires further improvements.

Analysis of pilot system data quality identifies room for further improvement through user training and clarification of assessment and data entry expectations. Each successive generation of handheld software offers more powerful features and greater control of user input. Together, further training and improved handheld formats should result in further improvements to data quality and completeness.

Quantifiable costs of the pilot system - although greater than those of the existing paper-based system - will become attainable as hardware costs decline and public health nursing costs rise. These costs also appear nominal compared with potential organisation and health system cost savings arising from the use of captured information for evidence-based planning.

Based on pilot study findings, users themselves represent the greatest resource for a full implementation of the pilot system. Nurses who used the system participated in its development at nearly every stage, providing excellent insight into problems with the system and possible solutions.

Users also present a challenge facing full implementation of the pilot system.

Implementers must provide adequate, effective and timely training and on-going support to users of *all* levels of computer experience. To help manage user expectations of the system, implementers must educate users of the initial costs in increased workload and benefits in having data for increased individual user and organisational planning.

Current applications

Designers have developed two additional perinatal health applications. For Prince Edward Island's Child Health Database, handheld units replace existing paper forms used to capture post-partum data on both mother and child from birth to six months of age. Regional and provincial aggregation of data collected from local offices permits comparative analysis of the impact of inter-regional programmes, and the potential for linkage with other data sets and analyses. This system is intended to complement the existing Island Health Information System (IHIS). For more information, please refer to Annex 14: Electronic data capture in local public health infrastructure development, East Prince Health, Prince Edward Island.

A second application developed for the Canadian Prenatal Nutrition Program's Accountability Tool, collects basic perinatal information to meet National Treasury Board requirements. At the community level, the use of handheld computers also permits programme providers to utilise this data for local level planning. Through this application design, local program providers are able to analyse case load data quickly through user-friendly 'push button' analysis and reporting programs developed in Epi-Info 6. For assistance, users gain assistance from a toll-free technical support hotline[153].

Future directions

Several currently available innovations could further assist nurses in their jobs. Future handheld form development applications could interact with other existing handheld applications. Public health nurses would note client appointments on existing electronic organisers (for example, Pocket Outlook) that use the contact information database as an address book. For some parts of Canada, electronic handheld maps are available that could assist a nurse in locating and finding their way to a client's home.

Two innovations currently in development offer new opportunities for the future use of handheld computers for routine data capture. The first is the development of voice-recognition software to convert vocal speech patterns to text. Already available for desktop computers in varying levels of sophistication, future, more powerful handheld computer models may be able to run compact versions of voice-recognition software. Voice-recognition offers a sophisticated alternative to the slow and tedious stylus-based input, and could offer a tool to address the problem of questions that yield highly heterogeneous responses. It may also present an opportunity to incorporate handheld computers in more qualitative research.

A second innovation already implemented in a number of commercial settings is wireless access. Instead of creating, editing and modifying records in a stand-alone database contained in one's handheld, wireless access allows one to access records located at a central database in *real time*. Different handheld users can access records in the same database, allowing the most up-to-date information to be available to all users. Although a number of handheld computers models currently available on the market already have wireless access capabilities, what's needed is the development of more sophisticated encryption systems to protect client data confidentiality. As commercial applications require more sophisticated security, these features will likely become available.

The ideal pilot study

The perspectives ascribed to Fuchs and Garber[154] and Goodman[155] illustrate comprehensive approaches to health technology assessment that evaluate all aspects of the technology. Time and resource limitations prevented this pilot study from measuring key considerations, such as the pilot system's actual impact on health. Analysis of data from the three month pilot study requires translation to public health nursing programmes and practises long before the realisation of improved health outcomes could be measured.

In an ideal setting, health technology assessment and technology development and implementation should occur separately. To avoid a potential conflict of interest, separate parties would oversee the two processes, allowing more resources to focus on the two endeavours.

On the development and implementation side, increased opportunity for system pre-testing, user training and use of the technology on a provisional basis would favour better integration of the system into daily work. Pre-testing should occupy between 4-6 weeks, and assign several target users (in this case, PHNs) full-time to the task of testing all aspects of the system for errors and glitches, and re-testing revisions of the system until errors became infrequent. During this time, developers and pre-test users would produce a paper-based reference manual.

Target users involved with pre-testing would then train other nurses to use the system. Managers would assign time during the day when new users would practise using the system - first entering mock clients - until they became comfortable enough to teach others how to use the system. New users would also benefit from the longer, exhaustive pre-testing phase, since their exposure to fewer errors and glitches would result in greater observability, and hence confidence in the system.

In addition to the public health nurse attitude towards computers questionnaire, the assessment would include a client satisfaction instrument to gain the client perspective of use of the handheld computer.

In contrast to clustering the pilot study in public health offices of the Industrial Cape Breton Municipality, random selection of pilot site offices across the health region would help control for inter-office differences, and possibly differences between clients in their respective service catchments.

Finally, following analysis and implementation of key findings in programme planning, public health services would conduct a cross-sectional survey of the health region to measure changes in health status. These data could serve as the basis for an economic analysis of the cost per additional unit of health output gain.

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Table 1: Comments on the pilot system grouped by theme

Time consuming	•In response to the statement "Computers will allow a nurse more time for the professional tasks for which s/he is trained." (Q18): "So far it is time consuming because the info we collect on computers is more." •In response to the statement "The time spent using a computer is out of proportion to the benefits." (Q20): "If we change the info - a tick off is easier than the palm and faster." •In response to the statement "Computers cause nurses to give less time to quality patient care." (Q25): "At present [yes], but we can improve to use less time."
Little perceived benefit	•In response to the statement "Computers save steps and allow the nursing staff to become more efficient." (Q32): "They can but not yet." •In response to the statement "Increased computer usage will allow nurses more time to give patient care." (Q34): "For stats, yes, but not patient care charting yet."
Benefits	•"The computers will however help with stats."
Satisfaction with system	•"Everything seems straight forward and logical."
Pilot study chart content requires improvement	•"Answers to some of the questions are not appropriate in certain situations. " •In response to the statement "Paperwork for nurses has been greatly reduced by the use of computers." (Q29): "Chart has increased in pages and increased in paperwork." •"I feel we need to improve what questions and responses we have. "
More practice needed	•"Not enough preparation and time before mandatory." •"Not enough time to practise using handheld and computer with this particular project." •"I struggled with trying to remember and I often forget what was shown to me."
Additional training needed	•"Feel keyboarding course would help pick up speed and therefore make it more likely to use computer for everyday tasks (ie. writing letters, etc.)." •"I believe computers are a great benefit to nurses but I believe we need more support and training to have them considered an asset and a time saver."
Handheld computer criticism	•"Palm held computers are not practical for their intended use. They are time consuming and do not allow you to elaborate on assessments when needed." •"Communication with client decrease when palm held computers are brought into the home." •"Palm takes too long in home and is not relationship building in a home. •"It distracted me and detracted from my interaction with the client so I put it away part way through [the client visit]." •"My last mom had a two and a half year old. At first, she was watching television, but about half way through it got her attention - she thought it was a Game Boy! Then she kept wanting to see it and play with it. After she started bawling, I had to put it away."

Data twice recorded: first, on old forms and later transcribed to handheld	•"Palm takes too long in home and is not relationship building in a home. Therefore must jot a few things down as we did before. If there were [client health] problems, we checked things off on a sheet and jotted notes next to it. Then put it on palm, then computer, then print. We still have to check computer read out, fill out info on flow sheet, child health record, MCH9, social form, graph and blue family record, and then write up nurses notes. It was easier to do 2 check off sheets and a lot less paper."

Table 2: Peer Audit Summary Report data elements used

Data element	Used?	Notes
Chart/family folder complete?	No	Prenatal information not collected in PCR
Demographics completed	No	Paper forms measure demographic data in prenatal period via a client self-administered questionnaire
Date of birth (new baby)	Yes	
Date of discharge (mother and baby)	Yes	
Date of document referral to PHN	No	Date of document referral to PHN not recorded in PCR
Date referral received by PHN	Yes	
Date of first PHN contact	No	Date of first PHN contact not recorded in PCR
Follow up occurred within 48-72 hours as per service protocol	No	Date of first contact was not recorded
Mother breastfeeding: if mother stopped breastfeeding before she wanted to, state reason given	No	Although reason mother not breastfeeding and breastfeeding problems recorded, whether mother stopped breastfeeding prematurely was not recorded.
Date of Telephone Assessment / Home visit	Yes	PCR combines telephone and home visit forms into a single form: only one assessment date is recorded. This variable was compared with the chart audit telephone assessment date.
Need and reason indicated why further follow up was to be done	No	Need and reason indicated in progress notes (not included in PCR)
Content of information on discharge referral was appropriate for planning post-partum service.	No	Specific criteria for assessment of this measure unclear.

Table 3: Proportion of completed data elements (selected) found in paper forms and pilot study forms

Data element	% completed in paper form	% completed in pilot study
Date of birth (new baby)	99% (339/344)	100% (107/107)
Date of discharge (mother and baby)	94% (322/344)	89% (95/107)
Date referral received by PHN	53% (182/344)	92% (98/107)
Date of Telephone Assessment / Home visit	95% (326/344)	96% (103/107)

Table 4: Summary of data quality estimation scores

Data element	Pilot system's sensitivity score (95% C.I)[1]	Atlee database's proportion completed[2]	Pilot system's proportion completed[2]	If proportion different, χ^2, p-value
Relationship status	0.63 (0.48-0.76)	113/113	93/113	21.9, p=0.00003
Maternal employment	-	-	88/113	144, p<0.00001
Number of previous c-sections	1.00 (0.79-1.0)	26/26	25/26	
Pre-pregnancy smoking	0.67 (0.52-0.79)	110/112	-	
Smoking during pregnancy	0.64 (0.47-0.78)	110/112	-	
Alcohol during pregnancy	-	-	-	
Attendance of prenatal classes	0.78 (0.63-0.88)	90/112	91/112	
Gravida	1.00 (0.90-1.0)	115/115	113/115	
Para	-	115/115	113/115	
Initiation of labour	0.53 (0.36-0.68)	113/113	94/113	20.7, p<0.00001
Induction	0.89 (0.73-0.96)	113/113	82/113	35.9, p<0.00001
Augmentation of labour	0.75 (0.51-0.9)	66/113	66/113	
Vaginal deliveries	1.00 (0.95-1.0)	113/113	113/113	
Forceps use	0.75 (0.22-0.99)	14/87	38/87	15.8,p=0.00007
Vacuum extraction	0.89 (0.51-0.99)	87/87	59/87	33.4, p<0.00001
Vaginal birth after previous caesarian	-	13/87	55/87	42.6, p<0.00001
Episiotomy	0.85 (0.68-0.95)	113/113	93/113	21.9, p<0.00001
Infant's sex	1.00 (0.91-1.0)	111/111	101/111	10.5, p=0.001
Birth weight	0.83 (0.37-0.99)	111/111	111/111	
Apgar - 1 minute	1.00 (0.73-1.0)	110/111	106/111	
Apgar - 5 minute	0.97 (0.88-0.99)	110/111	105/111	
Gestational age	1.00 (0.46-1.0)	103/111	101/111	
NICU admission	0.56 (0.35-0.75)	111/111	111/111	4.4, p=0.036
Average	0.83 (0.6-0.92)	0.88	0.84	-
n	19	21	20	-

[1]Sensitivity score calculated using Atlee database as reference gold standard
[2]Among matched records, proportion of records containing a response

Table 5: Estimated costs and potential savings of the Post-partum Client Record System compared with existing paper form system

Costs/savings per year for 37 Public Health Nurses (one handheld unit/person)

Costs		Potential savings	
Non-recurrent costs			
- Training of public health nurses in use of PCR system[a]	$1,850.00		
Hardware:			
- Desktop PCs (already in offices)	-		
- Handheld PCs with required cables and accessories[b]	$3,700.00		
Software:			
- E-mail/diskettes (already in offices)	-		
- WinZip program (already in offices)	-		
- Syware Visual CE Professional Edition[c]	$98.40		
Recurrent costs (annual)			
- Periodic software upgrades	$100.00	- Cost savings of generating future perinatal statistics which were produced in previous years[d,e,f]	$2844.50
Replacement hardware: - Protective sheets ($10 / 40 sheets)[g]	$10.00	- Cost savings by reduced printing/paper costs of forms 201, 202, 203	$324.00
		- Cost savings attributable to time required to complete original paper forms compared with time required to complete electronic forms[h]	$1500.00
Total estimated costs	**$5758.40**	**Total estimated savings**	**$4668.50**

Figure 1
Response to statement:
"Overall, Public Health Services' perinatal information is managed efficiently."
(Number of respondents)

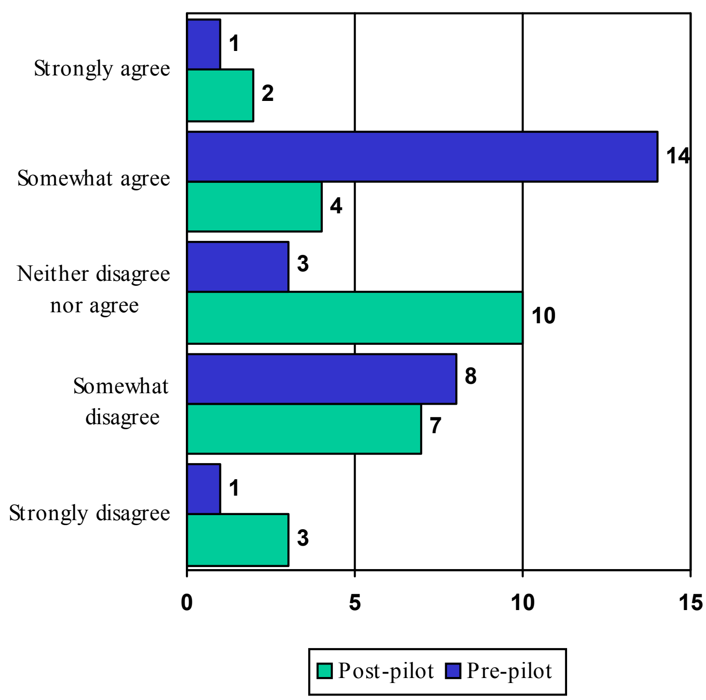

Figure 2
Response to statement:
"Overall, inter-agency perinatal information is managed efficiently."
(Number of respondents)

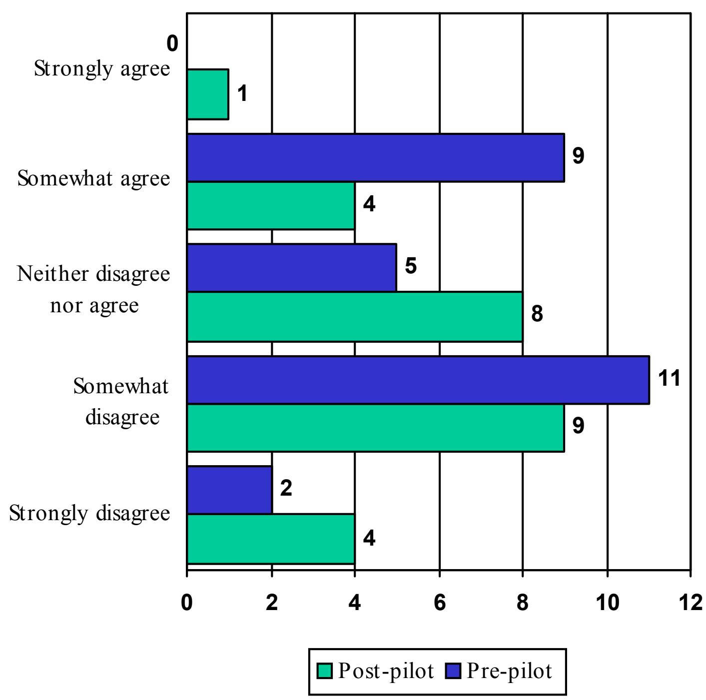

Figure 3
Response to statement:
"Overall, the current perinatal information system allows me to get information when ever I need it."
(Number of respondents)

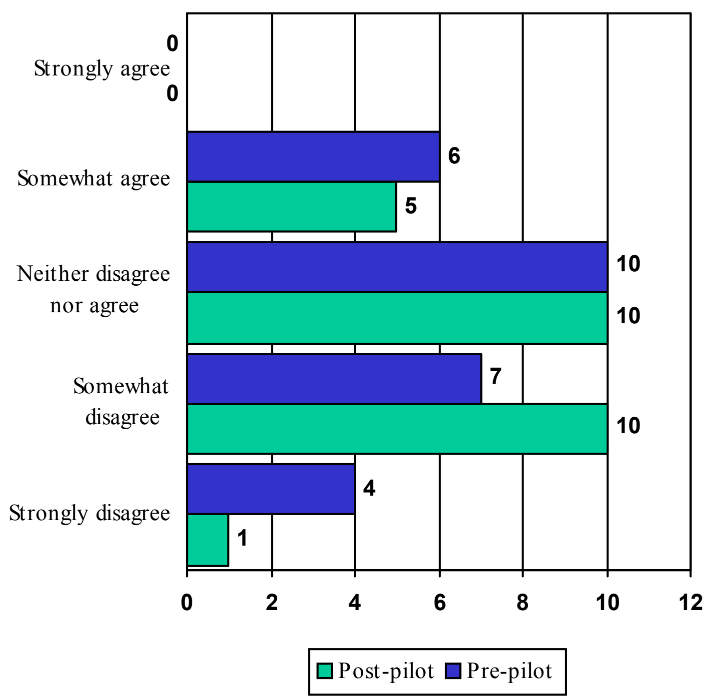

Figure 4
Response to statement:
“Overall, perinatal information found on client charts is always accurate.”
(Number of respondents)

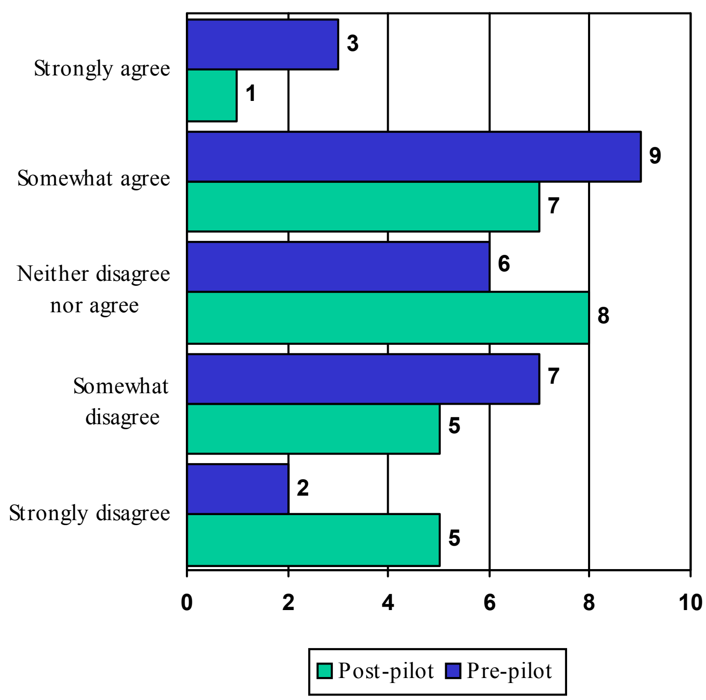

Figure 5
Response to statement:
"There is often information missing from a perinatal client's record."
(Number of respondents)

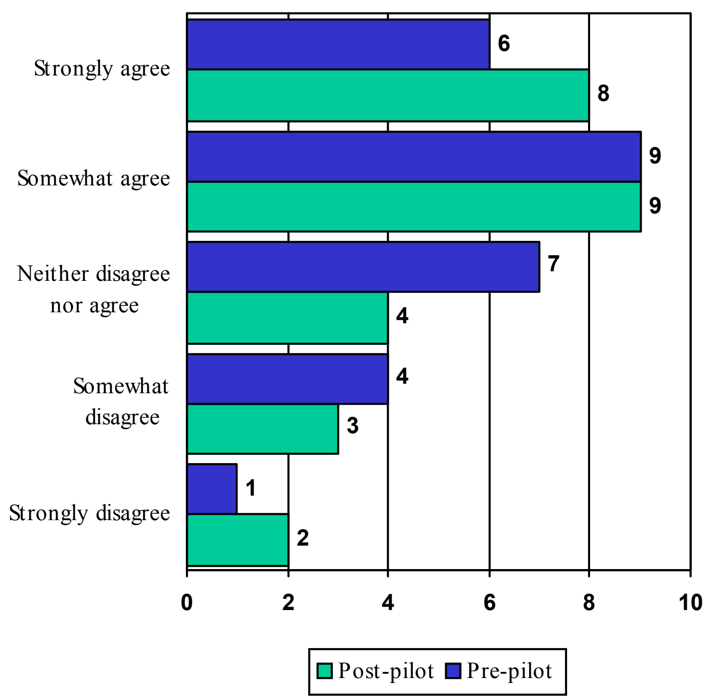

Figure 6
Response to statement:
"With the current perinatal information system, illegible information often leads to errors or delays."
(Number of respondents)

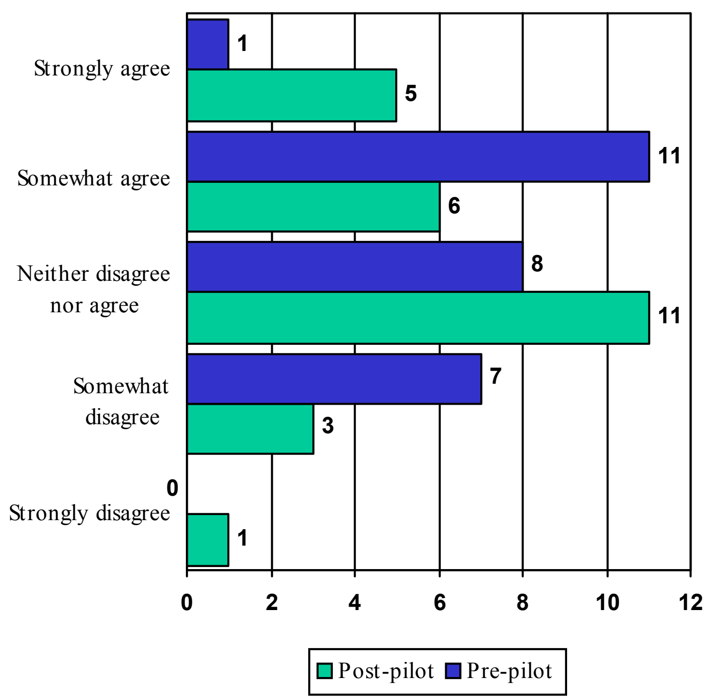

Figure 7
Response to statement:
"The current perinatal information system prevents information from flowing quickly between co-workers."
(Number of respondents)

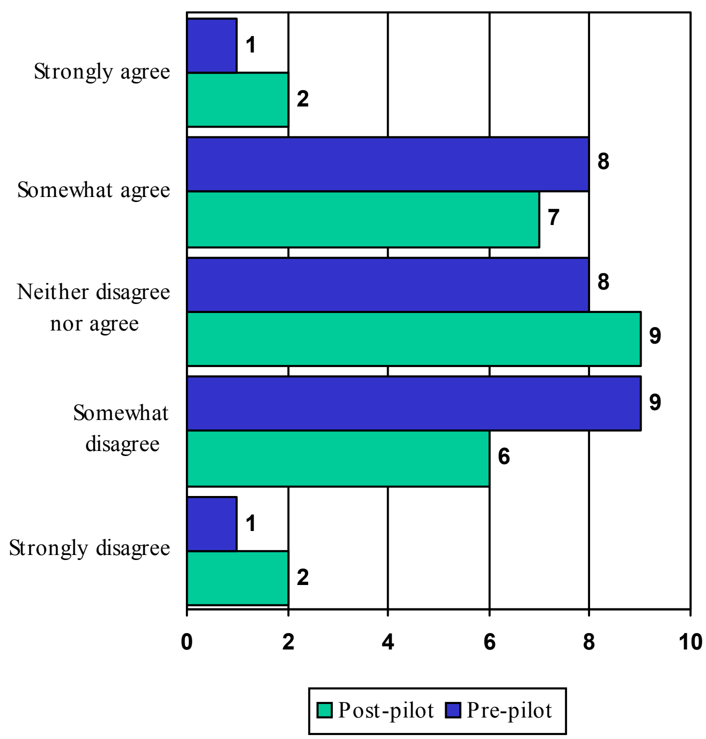

Figure 8
Response to statement:
"In the current perinatal information system, clerical work consumes a major portion of my time."
(Number of respondents)

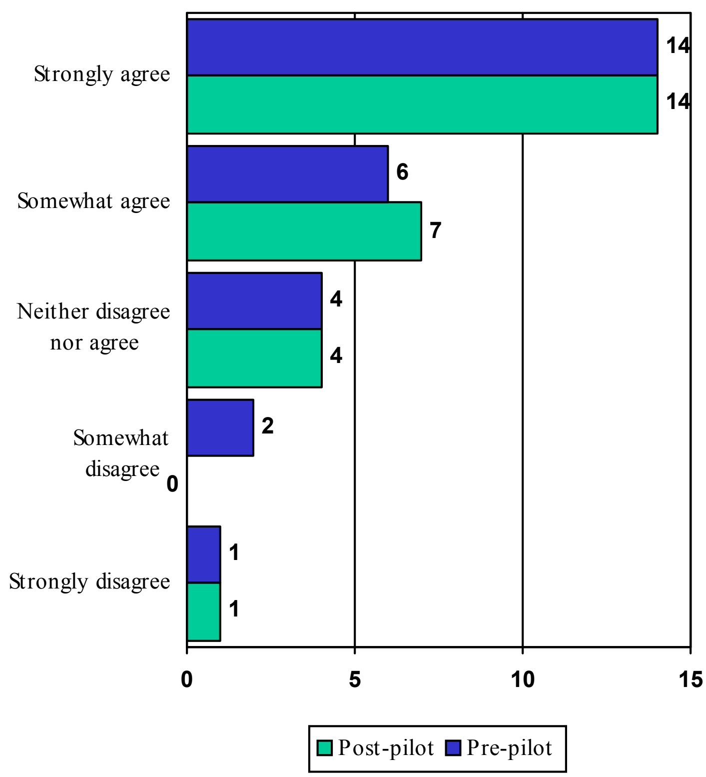

Figure 9
Response to statement:
"In the current perinatal information system, documents (eg. client records) are never lost."
(Number of respondents)

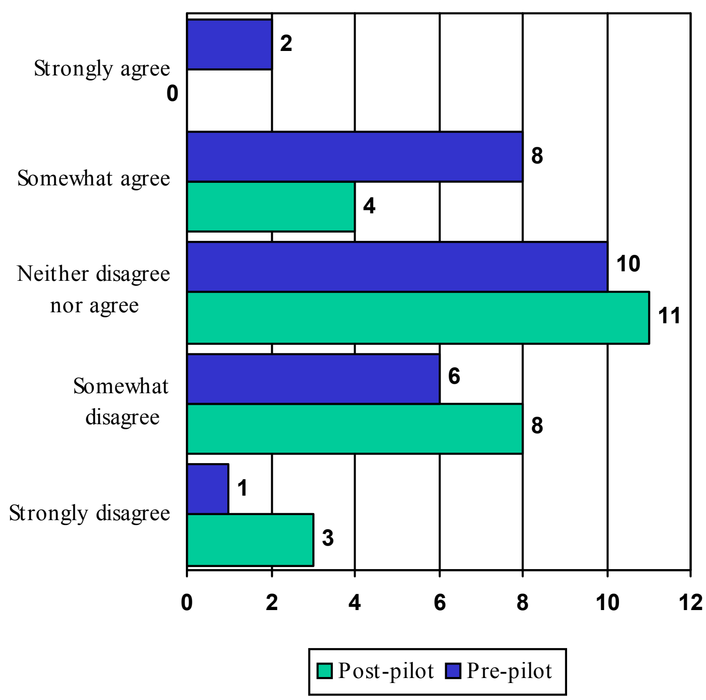

Figure 10
Response to statement:
"The current perinatal information system allows us to always address client needs with in the time suggested by our organization's practice guidelines."
(Number of respondents)

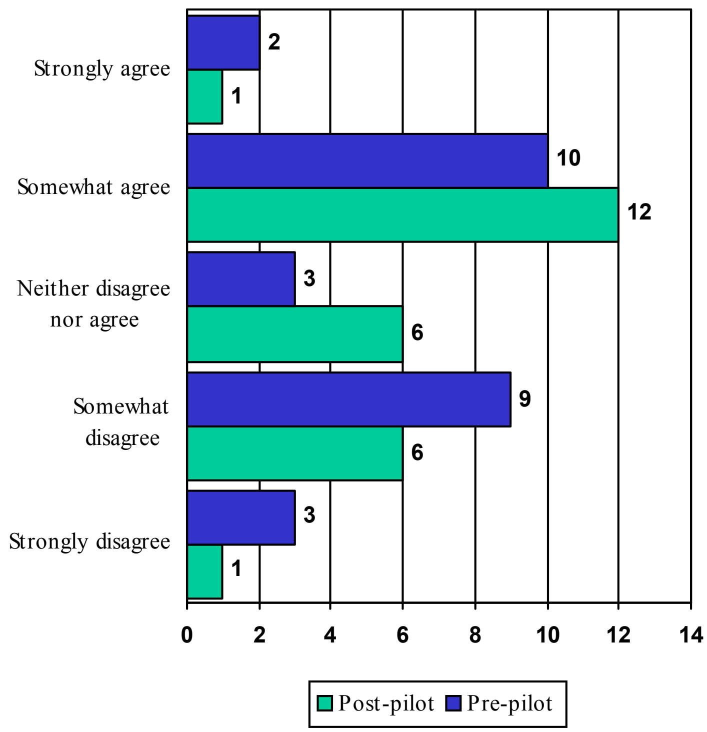

Figure 11
Response to statement:
"The current perinatal information system allows the same information to be available to several users at a time."
(Number of respondents)

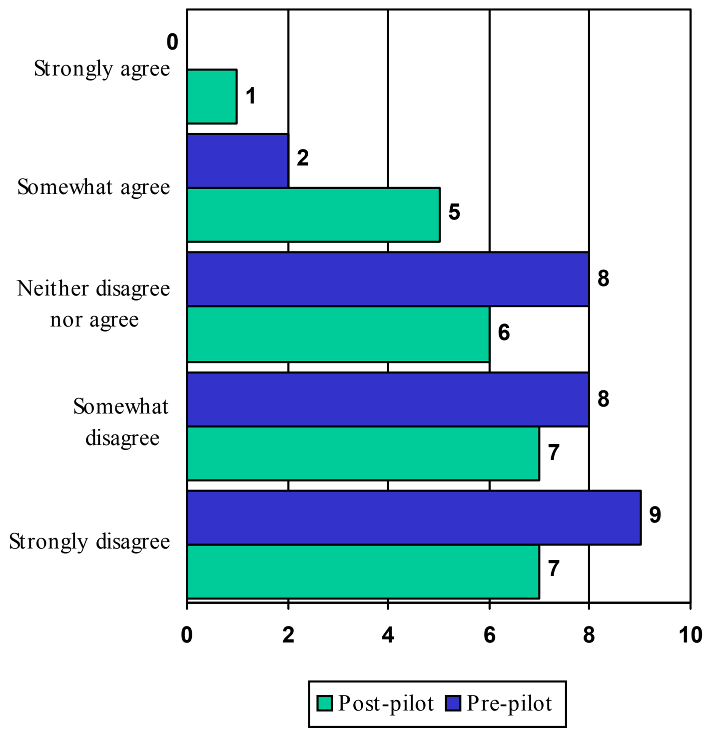

Figure 12
Response to statement:
“The current system allows perinatal information which is collected to be used for short-term organizational planning.”
(Number of respondents)

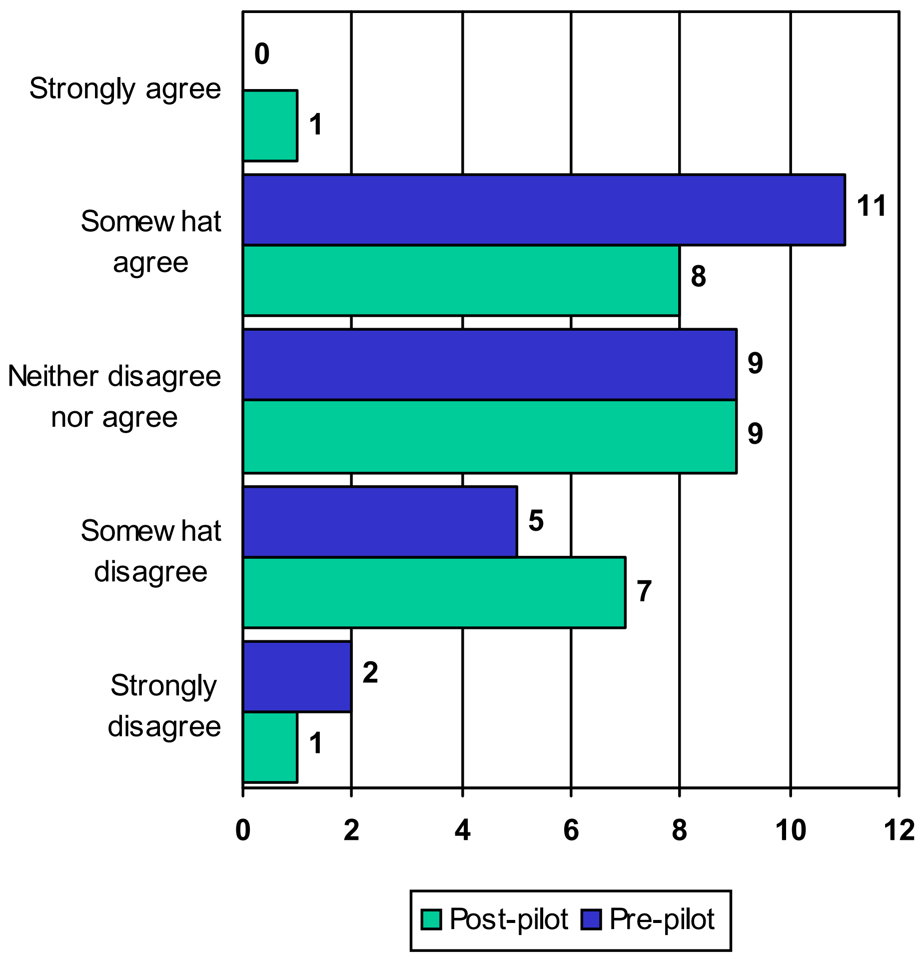

Figure 13
Response to statement:
"The current system allows perinatal information which is collected to be used for long-term organizational planning."
(Number of respondents)

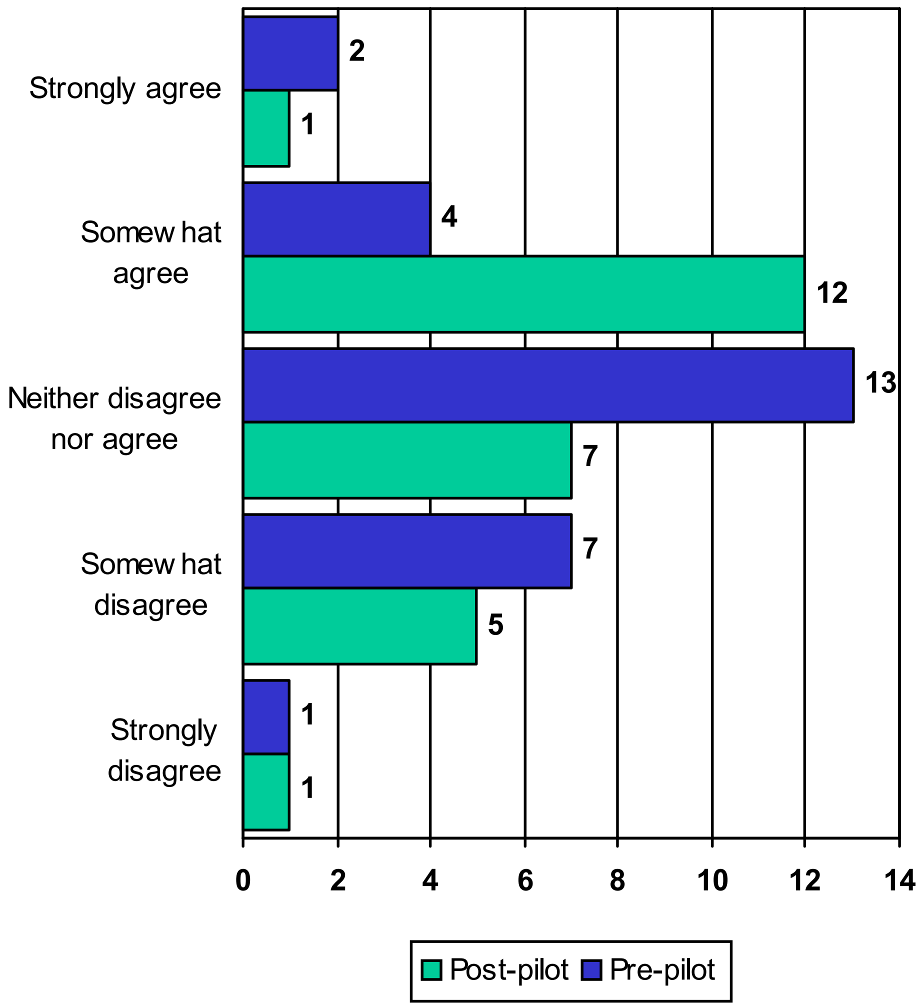

Figure 14
Response to statement:
"Overall, I felt I did not receive enough training to use the current *computer* system."
(Number of respondents)

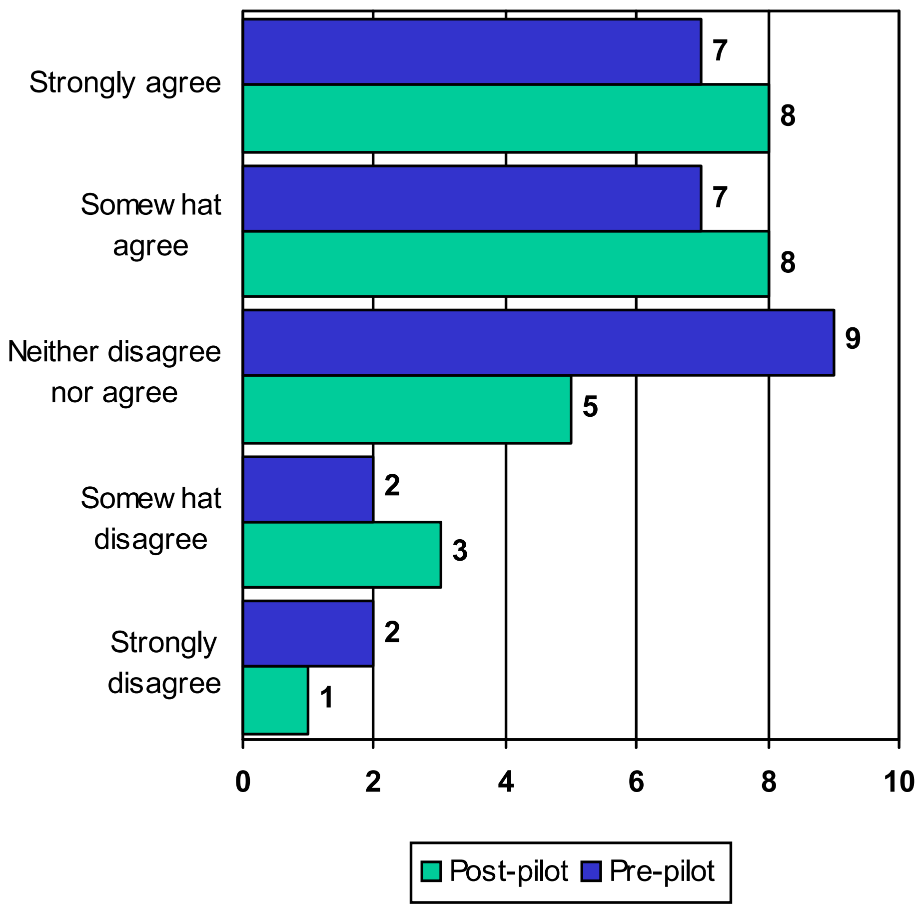

Figure 15
Response to statement:
"Training was offered soon enough to prepare me to use the current computer system when I needed to"
(Number of respondents)

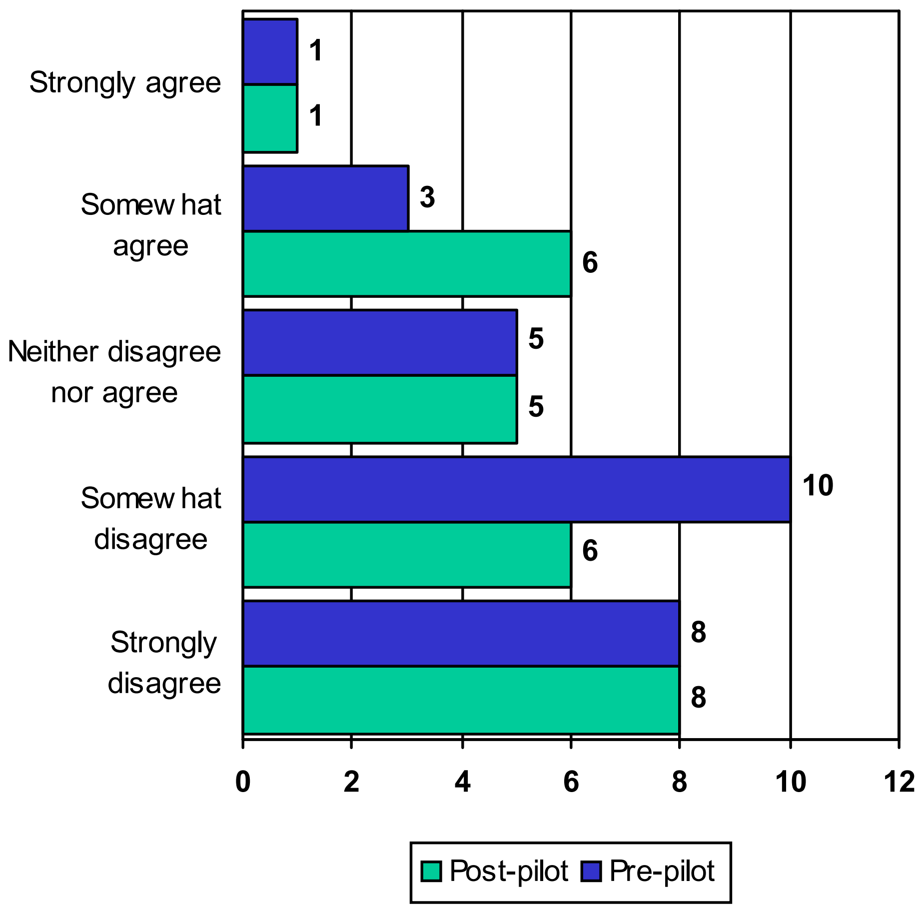

Figure 16
Response to statement:
"Orientation for new employees takes longer because of computers and, therefore, unnecessary work delays occur."
(Number of respondents)

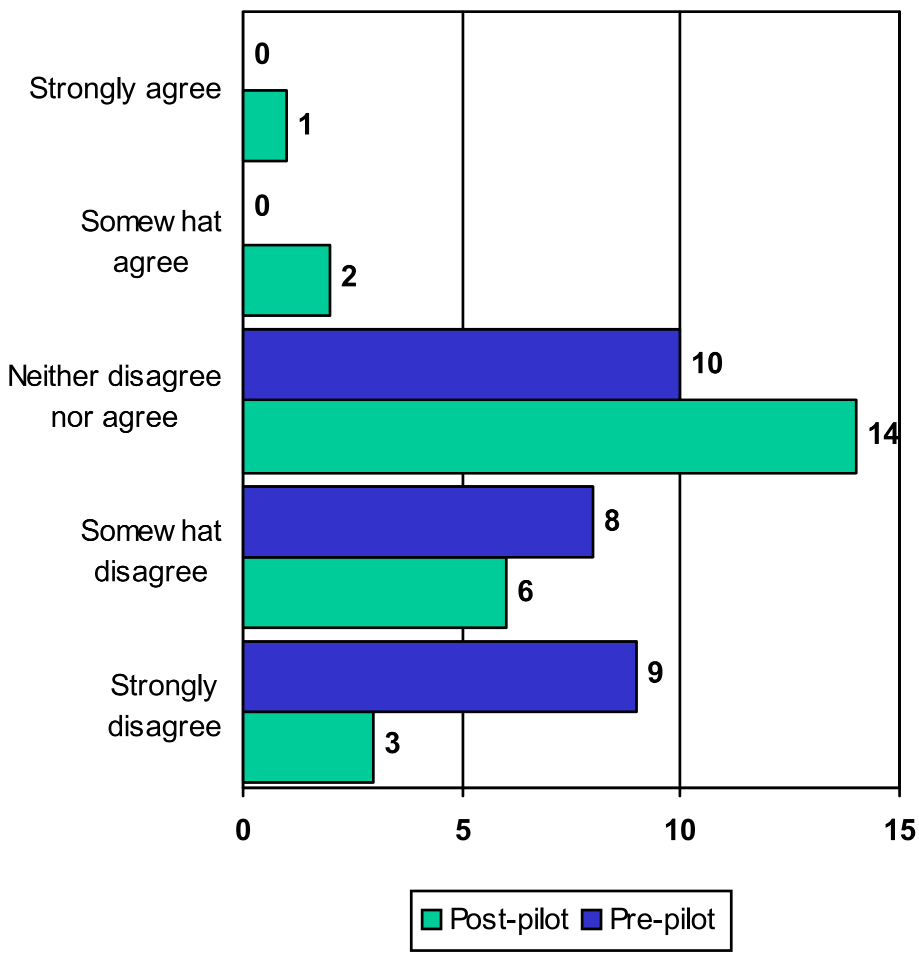

Figure 17
Response to statement:
"Compared with my co-workers, I am slow at learning how to use the computer."
(Number of respondents)

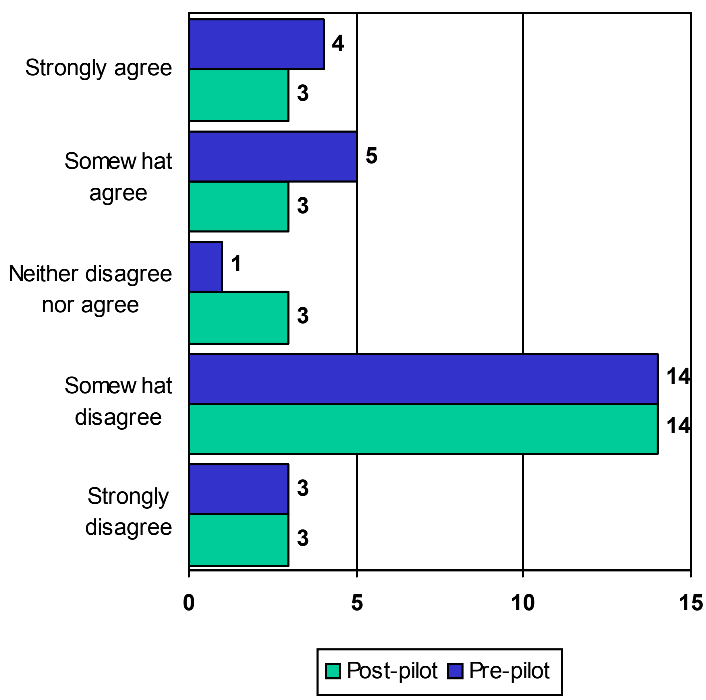

Figure 18
Response to statement:
"A computer increases costs by increasing a nurse's workload."
(Number of respondents)

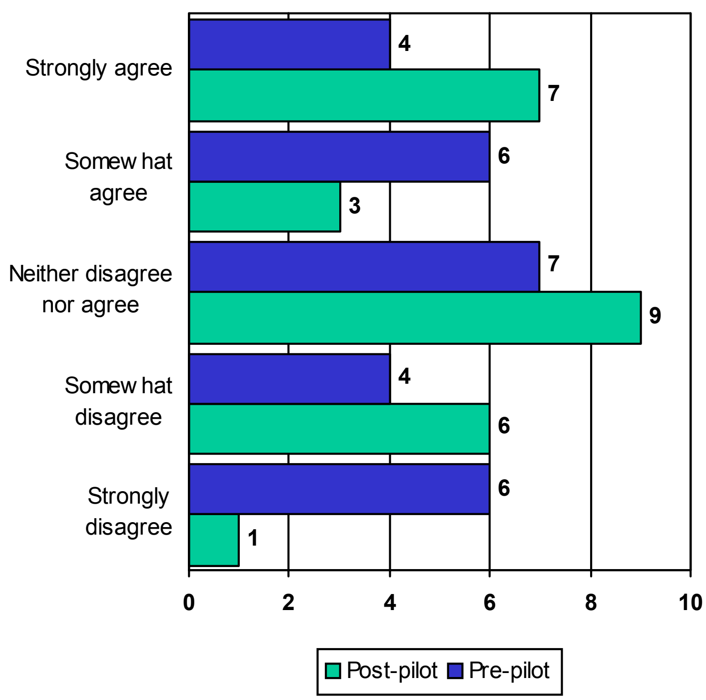

Figure 19
Response to statement:
"Computers will allow a nurse more time for the professional tasks for which s/he is trained."
(Number of respondents)

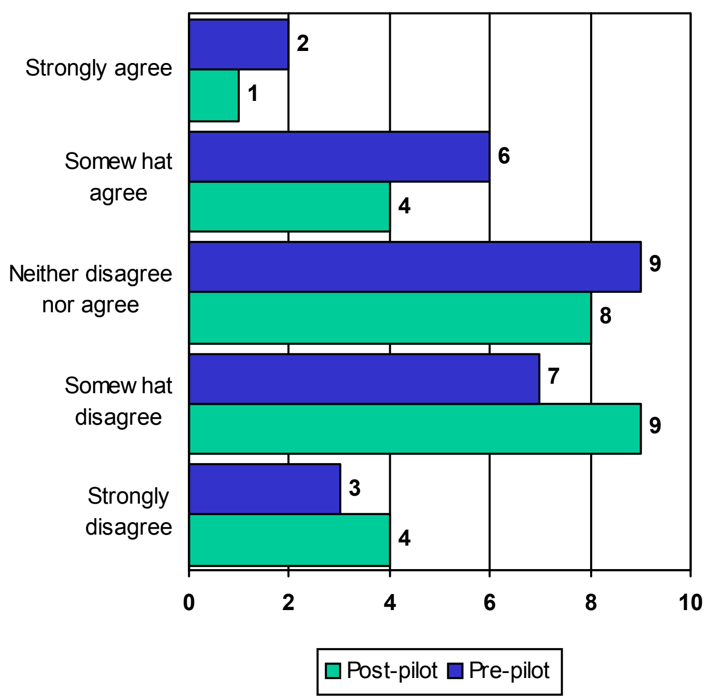

Figure 20
Response to statement:
"Part of the increase in costs of health care is because of computers."
(Number of respondents)

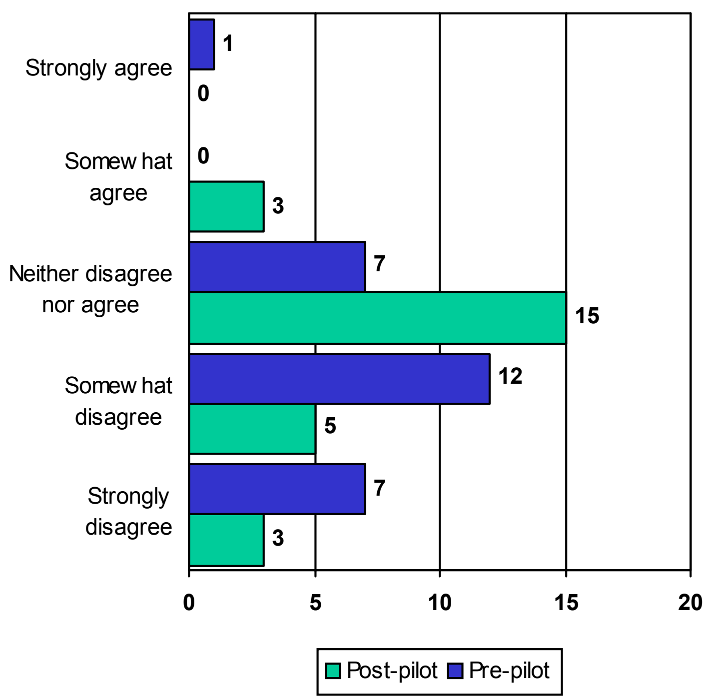

Figure 21
Response to statement:
"Only one person at a time can use a computer terminal and therefore, staff efficiency is inhibited."
(Number of respondents)

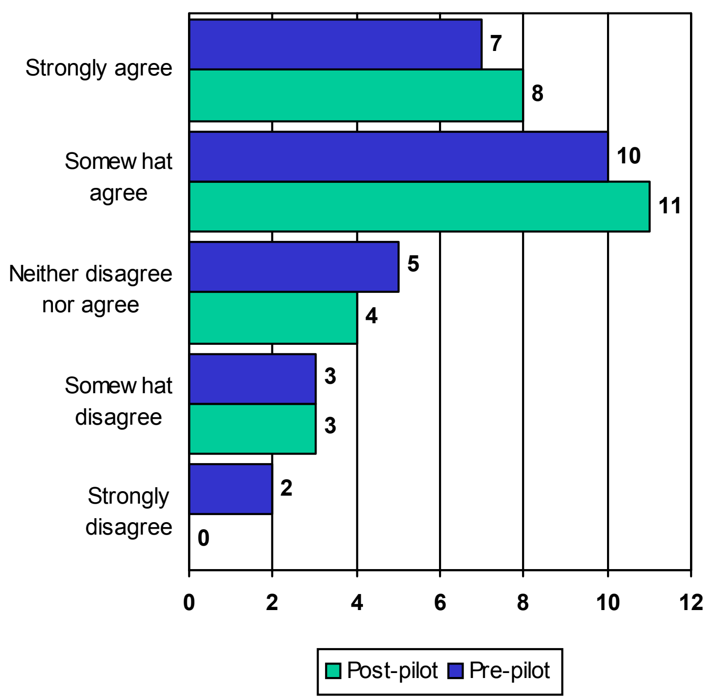

Figure 22
Response to statement:
"Computers cause a decrease in communication between health services."
(Number of respondents)

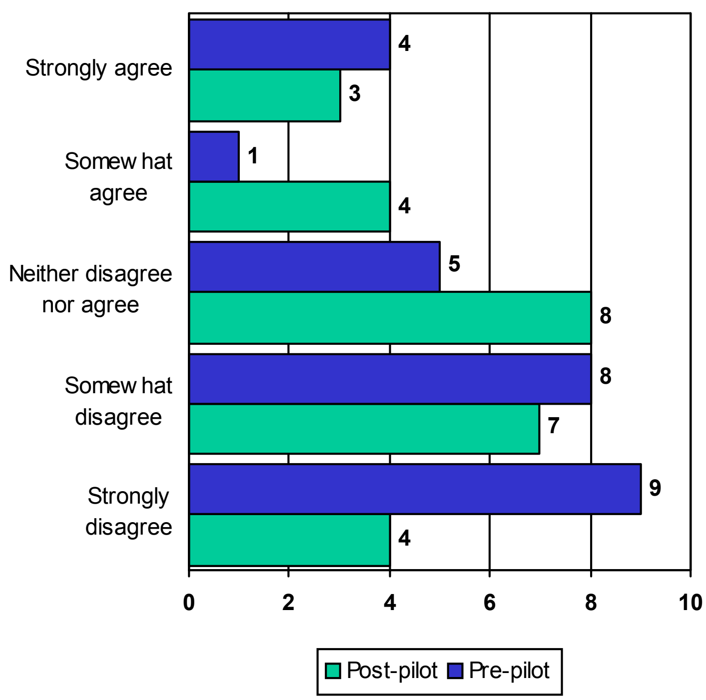

Figure 23
Response to statement:
"The time spent using a computer is out of proportion to the benefits."
(Number of respondents)

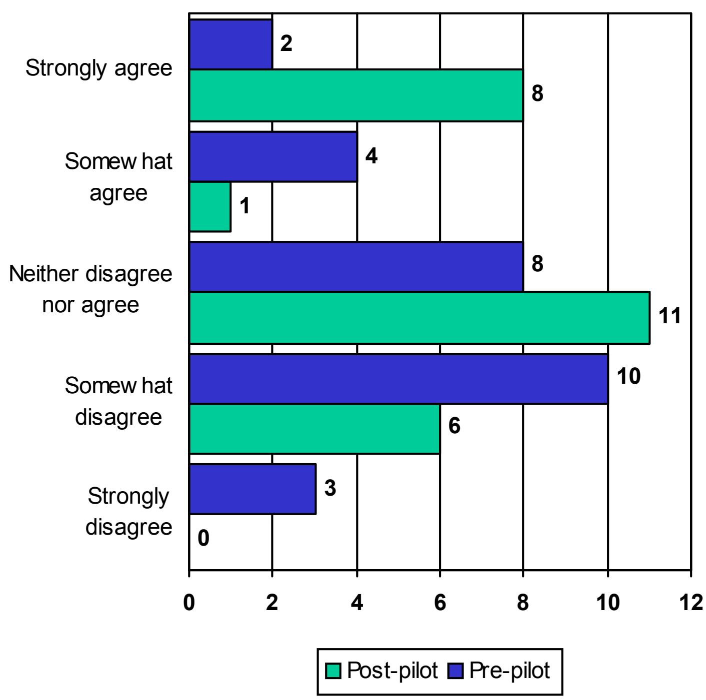

Figure 24
Response to statement:
"Computerization of nursing data offers nurses a remarkable opportunity to improve patient care."
(Number of respondents)

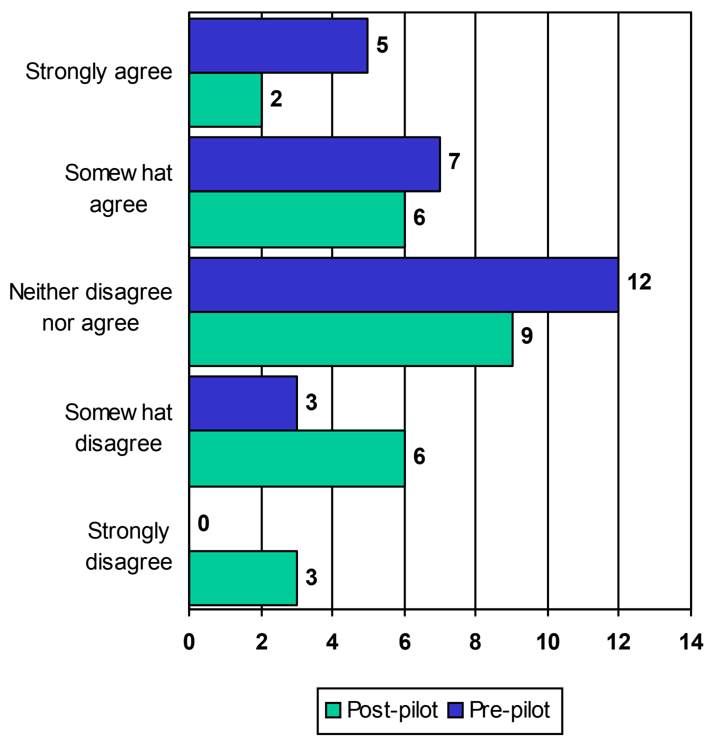

Figure 25
Response to statement:
"Computers cause nurses to give less time to quality patient care."
(Number of respondents)

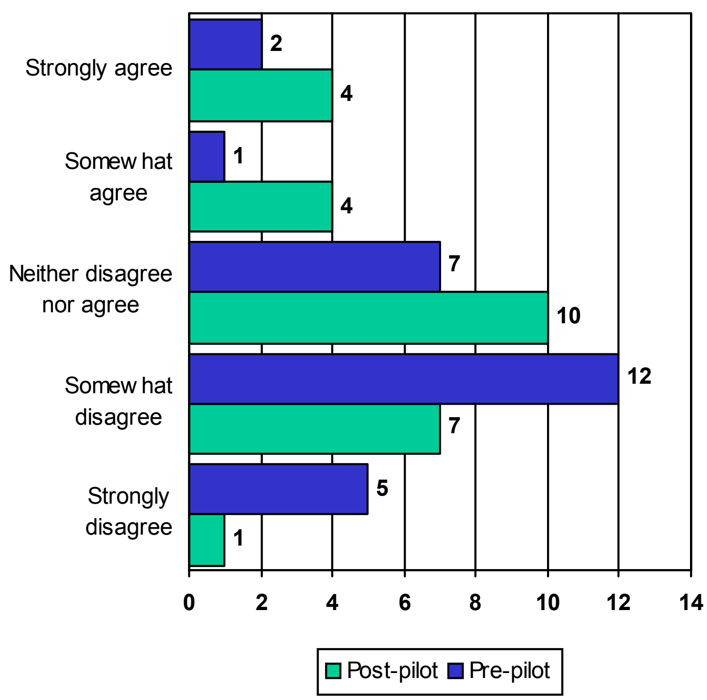

Figure 26
Response to statement:
“Computers make nurses[‘] jobs easier.”
(Number of respondents)

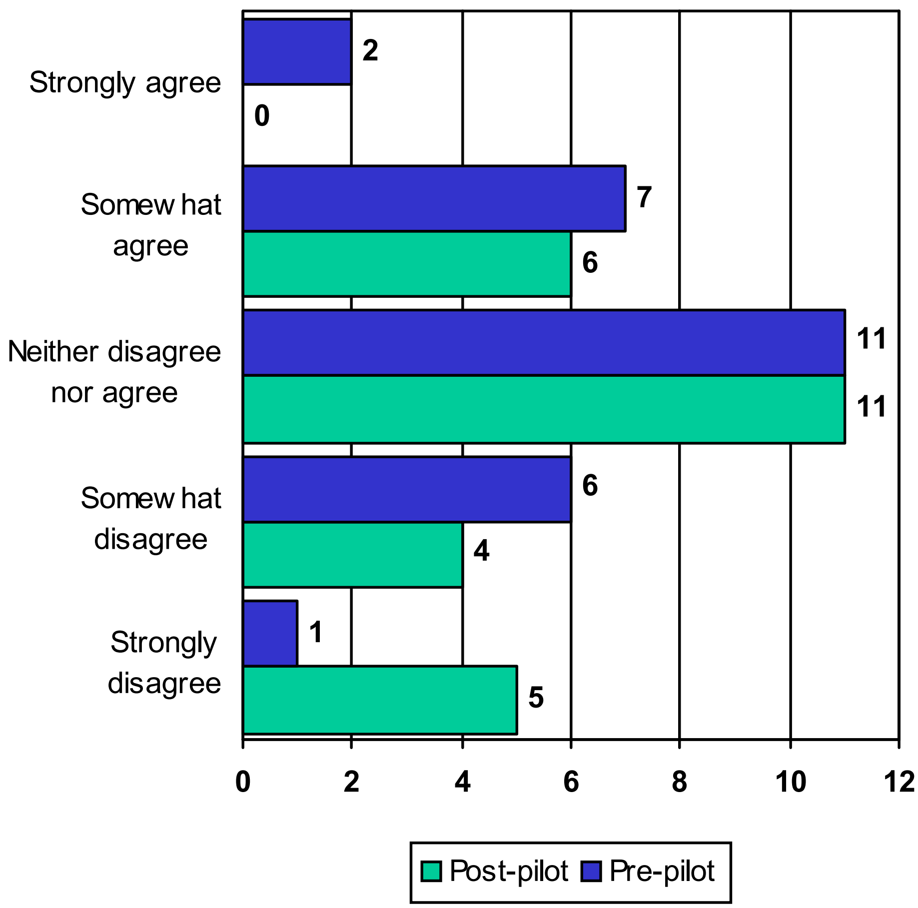

Figure 27
Response to statement:
"Paperwork for nurses has been greatly reduced by the use of computers."
(Number of respondents)

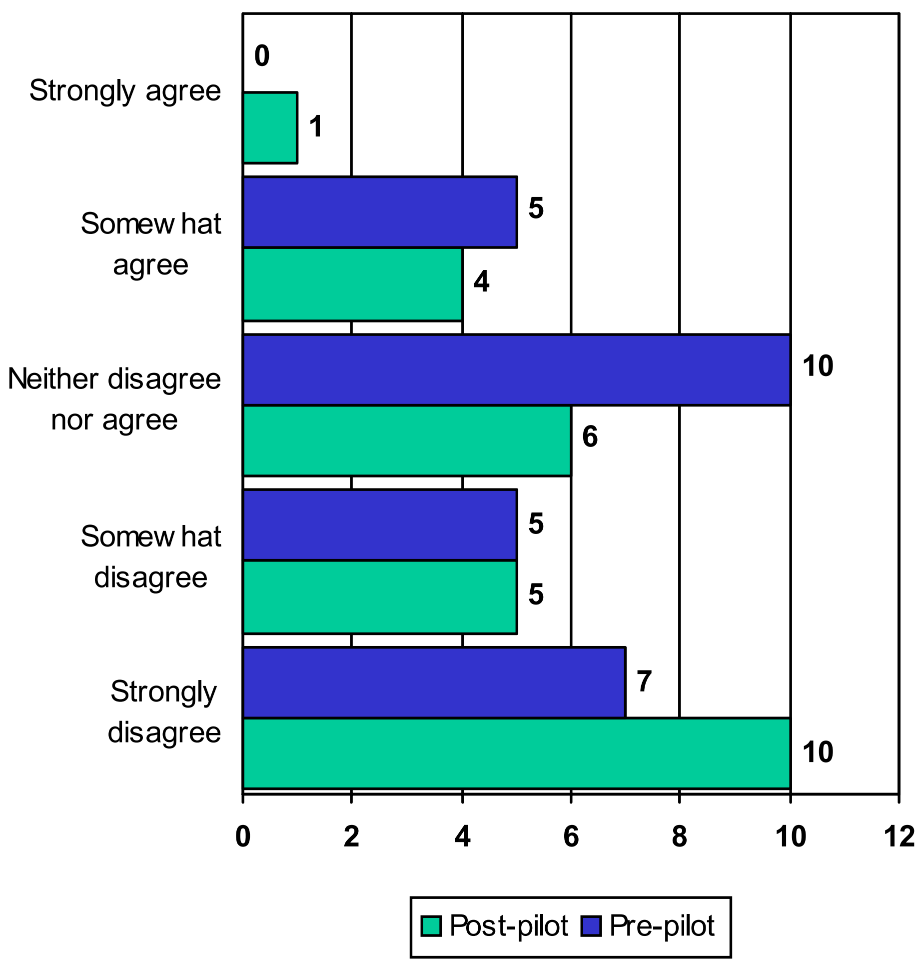

Figure 28
Response to statement:
"Computers save steps and allow the nursing staff to become more efficient."
(Number of respondents)

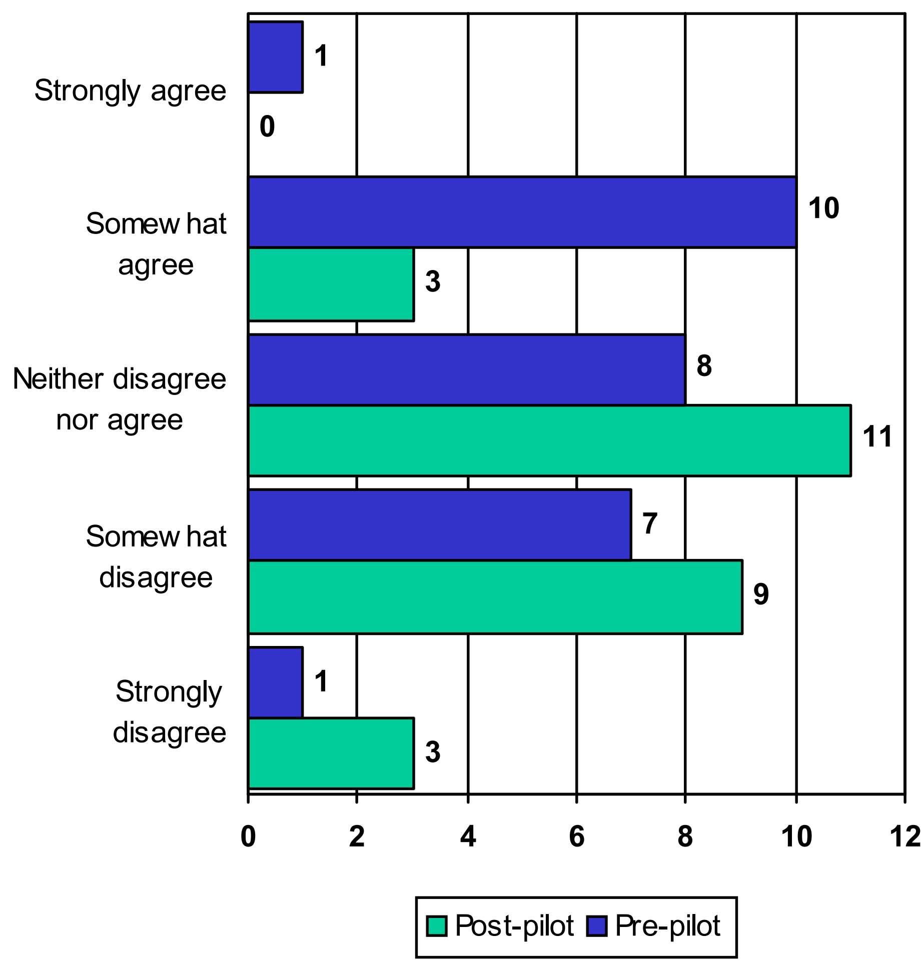

Figure 29
Response to statement:
"Increased computer usage will allow nurses more time to give patient care."
(Number of respondents)

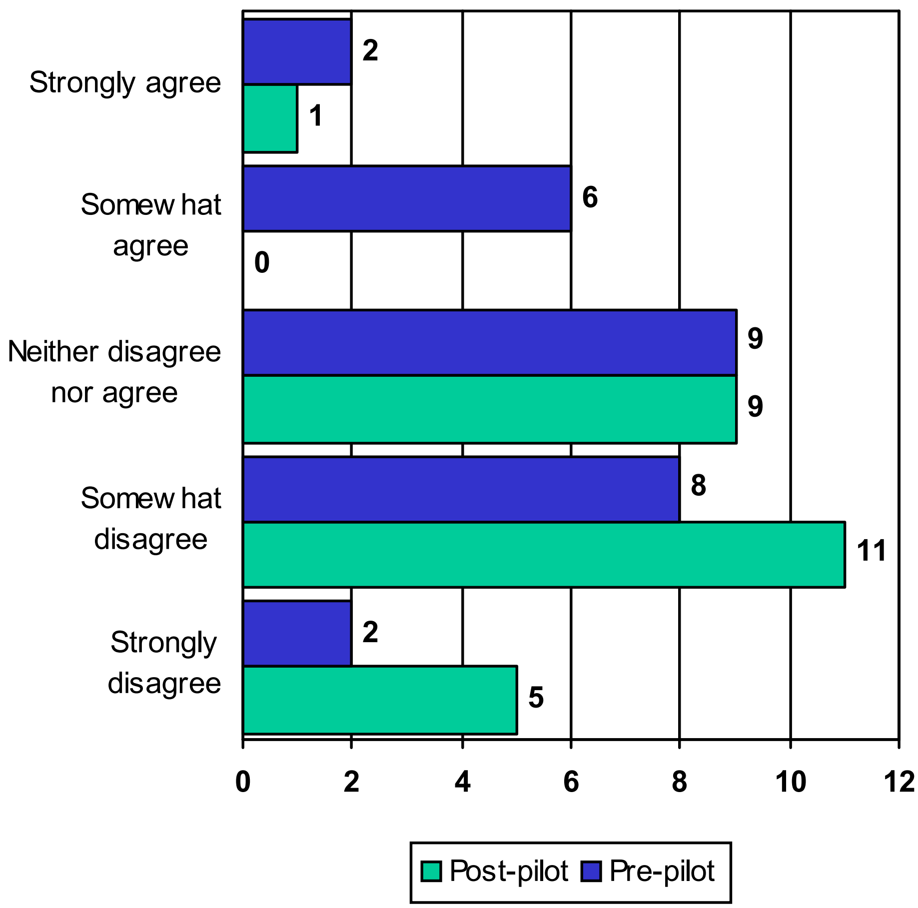

Figure 30
Response to statement:
“Computers represent a violation of patient privacy.”
(Number of respondents)

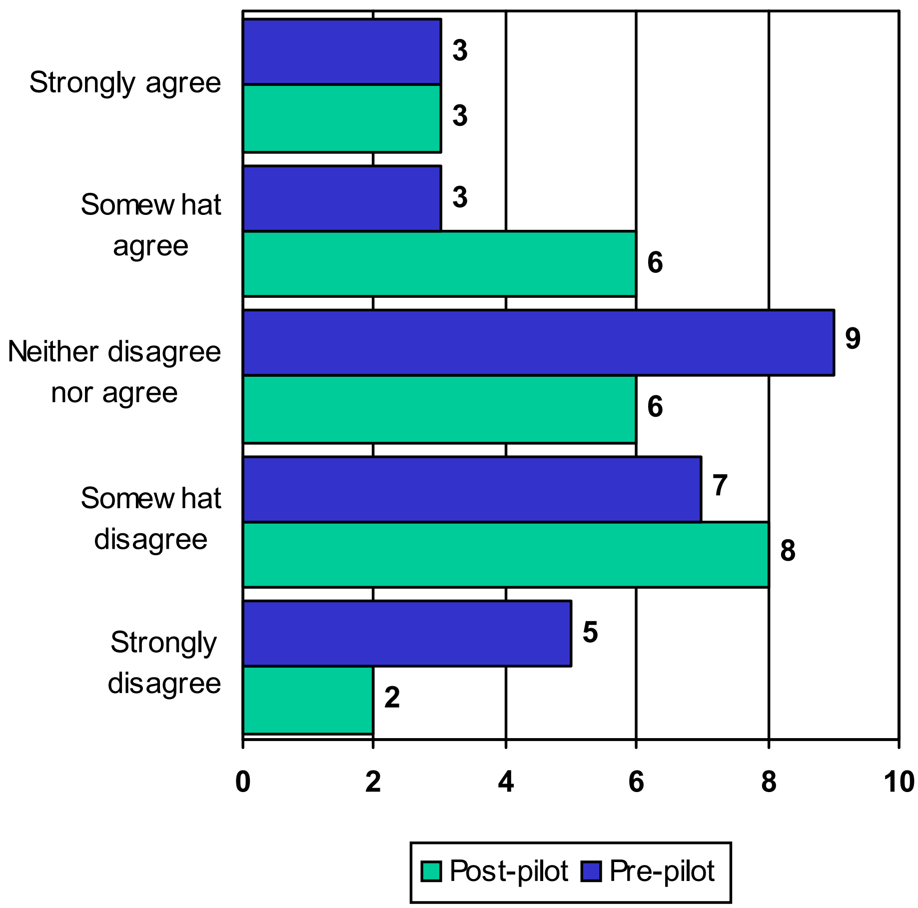

Figure 31
Response to statement:
"Computers contain too much personal data to be used in an area as open as a nursing station."
(Number of respondents)

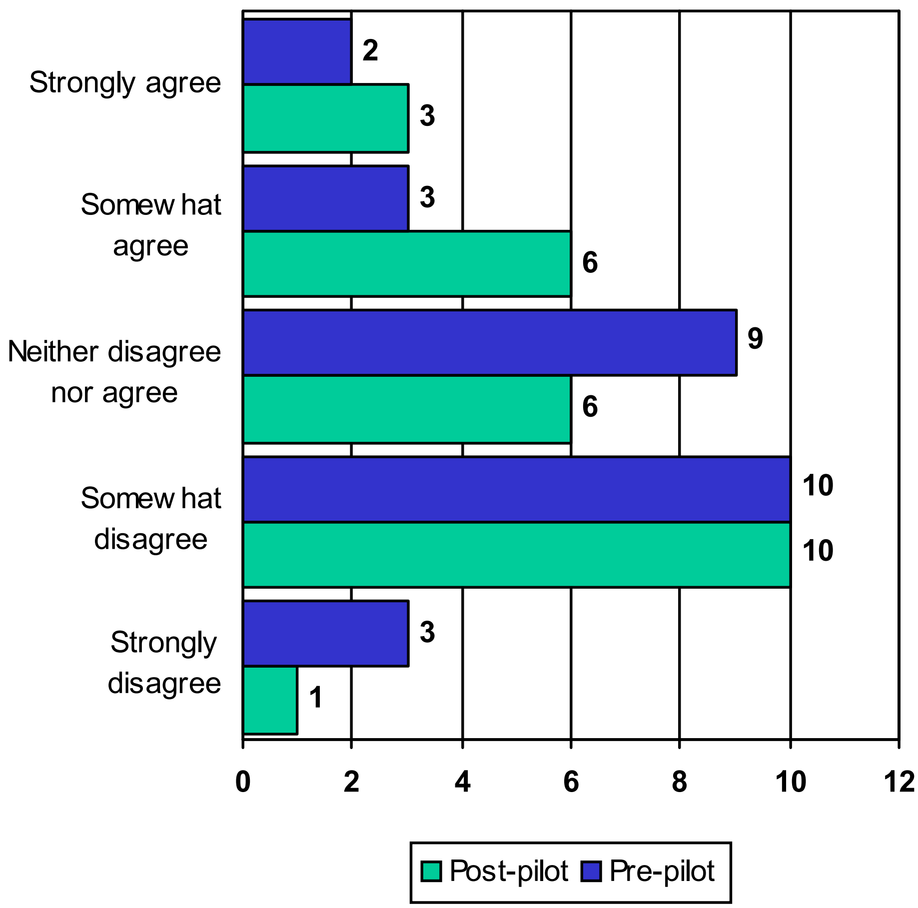

Figure 32
Response to statement:
"If I had my way, nurses would not ever have to use computers."
(Number of respondents)

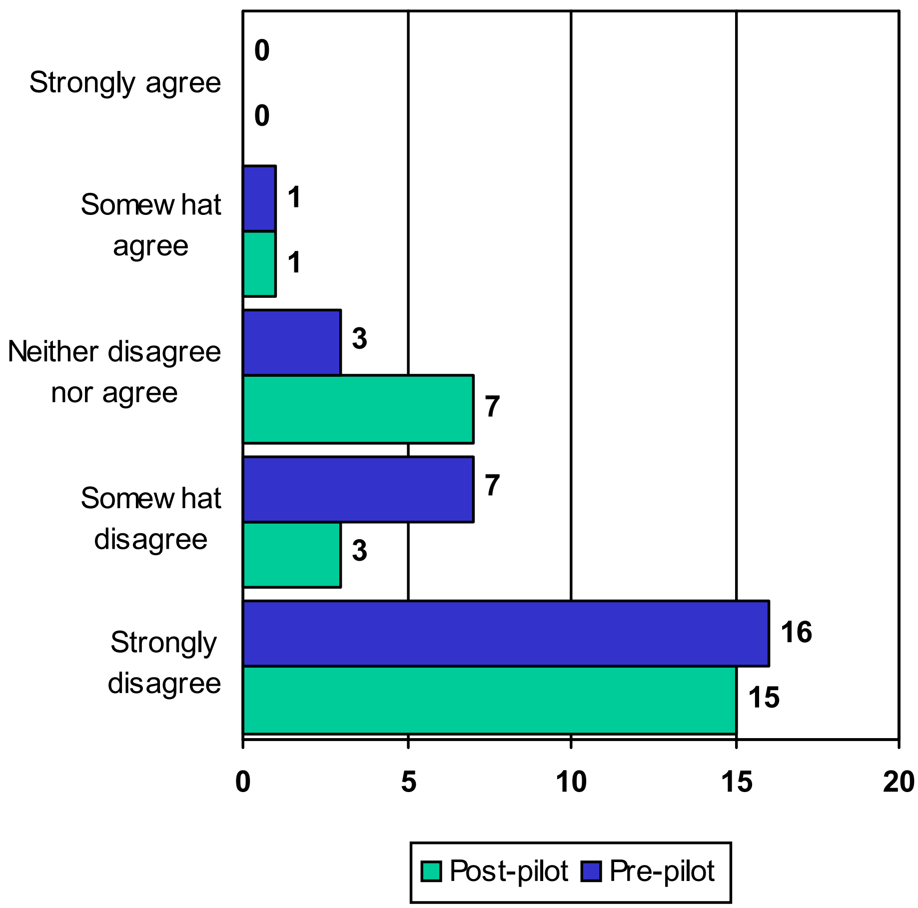

Figure 33
Response to statement:
"Computers should only be used in the financial department."
(Number of respondents)

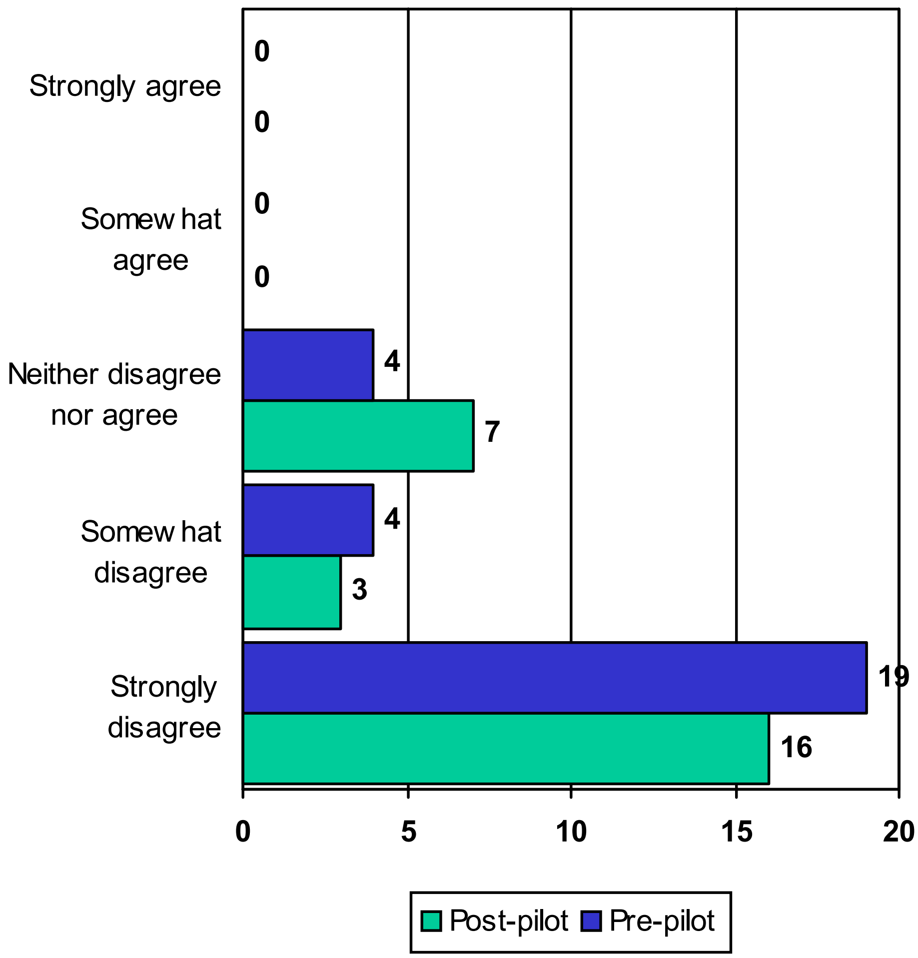

Figure 34
Response to statement:
"Nursing data does not lend itself to computers."
(Number of respondents)

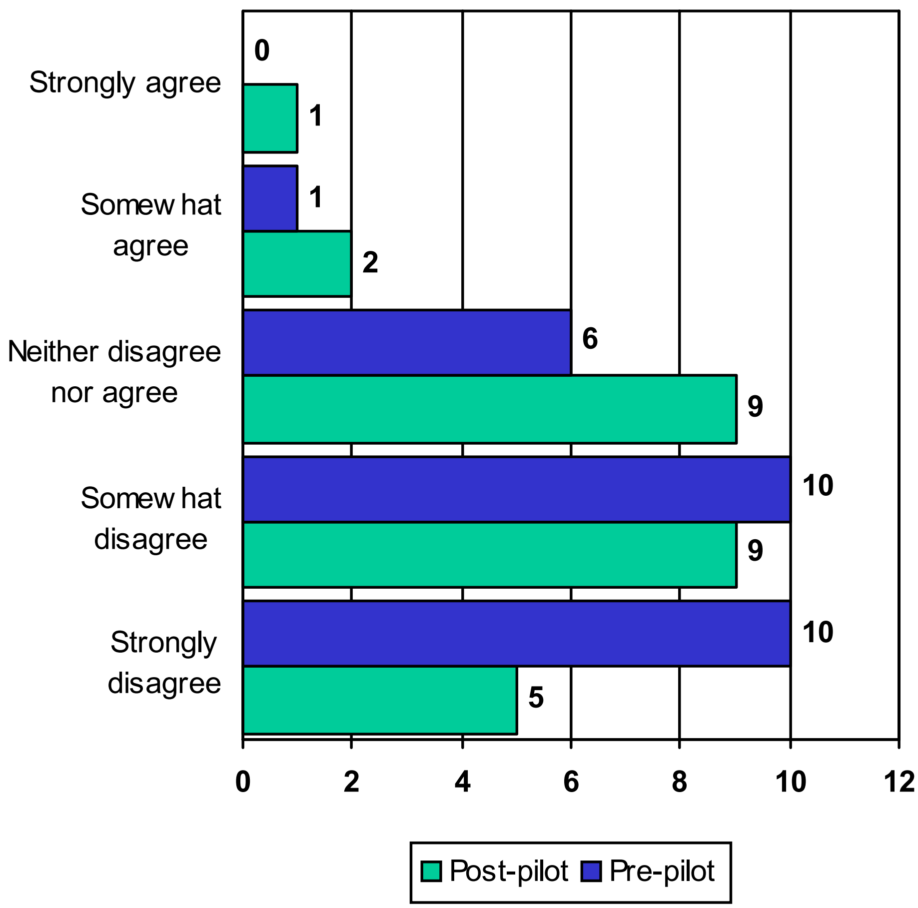

Figure 35
Response to statement:
"The more computers in an institution, the less number of jobs for employees."
(Number of respondents)

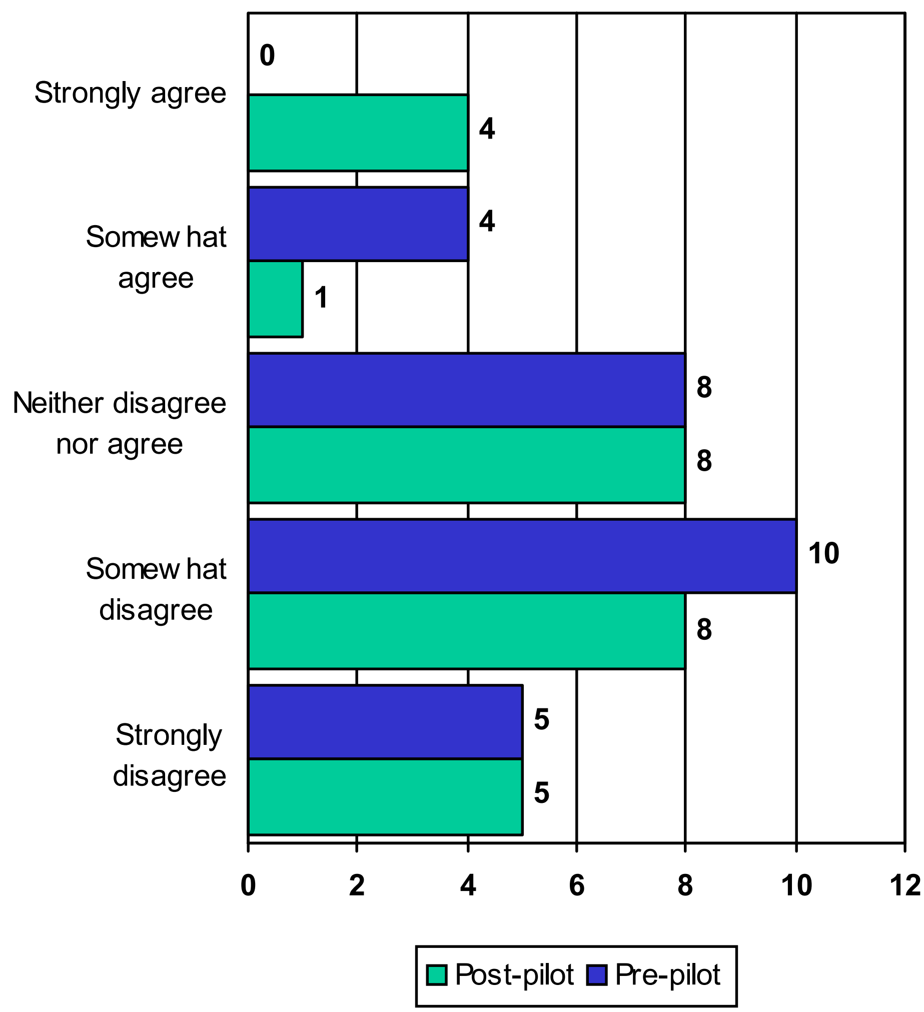

Figure 36
Response to statement:
"Because of computers, nurses will face more lawsuits."
(Number of respondents)

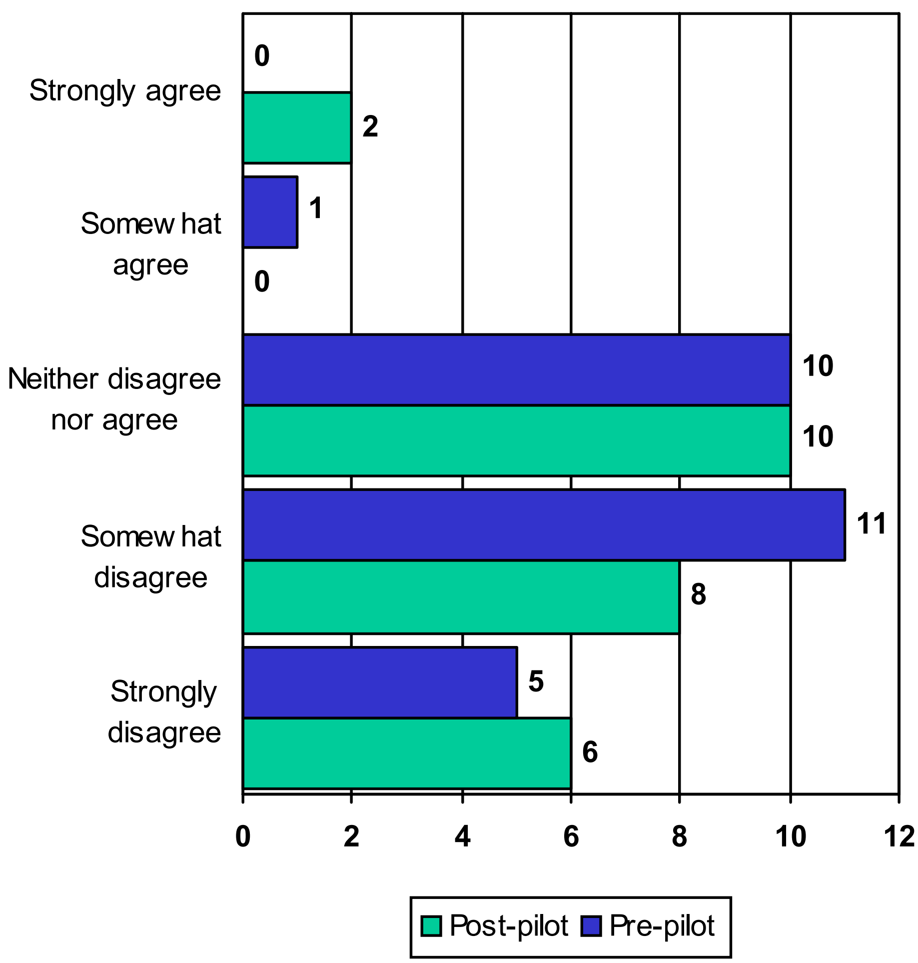

Figure 37
Response to statement:
"When possible, I try to avoid using a computer to complete a task."
(Number of respondents)

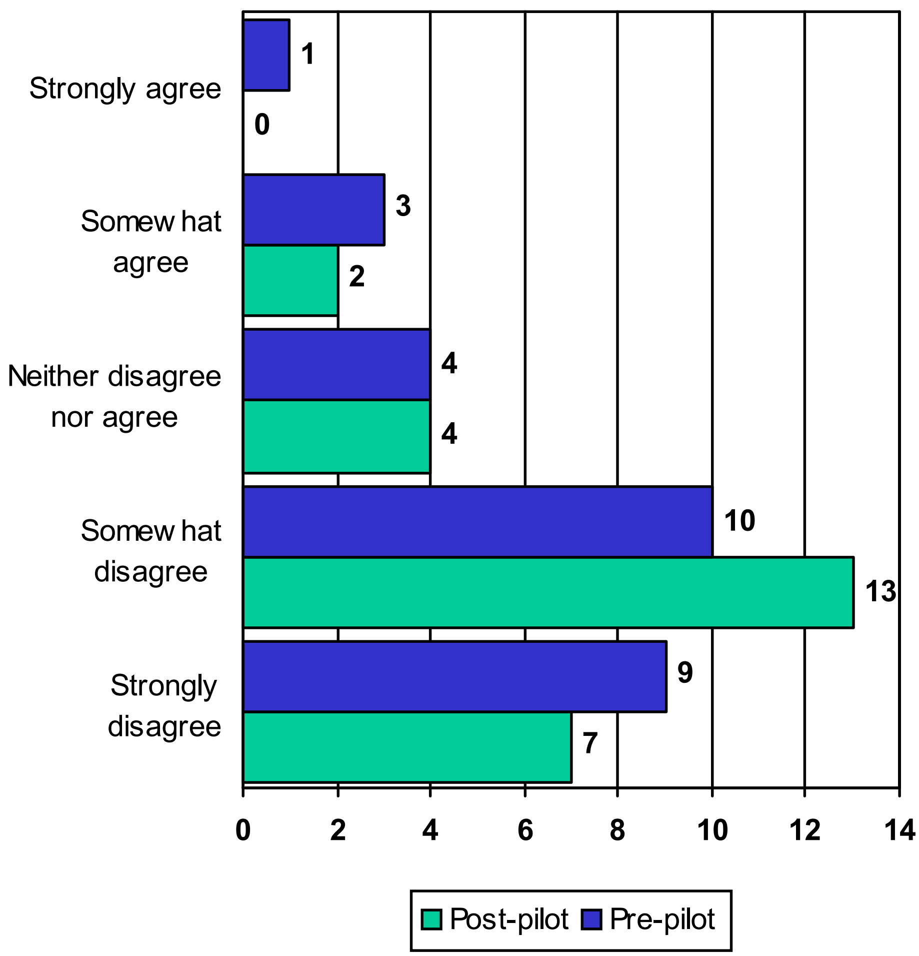

Figure 38: Equation used to estimate data completeness

Where:

$$DC = \sum_{n} \left(\frac{R}{R_T} \right)$$

- DC is the estimated data completeness.
- R is, for a given data element in the compared system, the number of records with data (that is, not a null or no data value).
- R_T is, for a given data element in the compared system, is the total number of matched records.
- n is the total number of data elements compared in the sensitivity score.