EVALUATING THE IMPLEMENTATION OF PICTURE ARCHIVING AND COMMUNICATION SYSTEMS IN NEWFOUNDLAND AND LABRADOR

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Evaluating the Implementation of Picture Archiving and Communication Systems in Newfoundland and Labrador

by

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Abstract

Evaluating the Implementation of Picture Archiving and Communications System (PACS) in Newfoundland and Labrador

In November 2007, the Newfoundland and Labrador Centre for Health Information (NLCHI) completed implementation of a provincial Picture Archiving and Communication System (PACS) on behalf of the provincial government. A benefits evaluation was undertaken to determine the impact that this PACS implementation had within the province of Newfoundland and Labrador.

The evaluation was carried out on the island portion of the province with a focus on 2 of the 4 provincial Health Authorities. The evaluation was guided by the report *Towards an Evaluation Framework for Electronic Health Records Initiatives* (Neville, Gates, MacDonald et al 2004), which emphasizes significant stakeholder involvement at each step of the evaluation, and triangulation of data where ever possible. The evaluation was designed as a pre/post comparative study utilizing project documentation, administrative data, surveys and key informant interviews as the primary data sources.

The findings of this study provide convincing evidence that clinicians, administrators and support staff strongly support the implementation of a provincial PACS. Factors contributing to the success of the provincial PACS included: a) a positive political and financial environment, and b) the approach

taken by NLCHI in engaging key stakeholders throughout the implementation, and through this process establishing a sense of ownership within the regional health authorities. The benefits of PACS, in particular, immediate access to historical and current exams and reports from multiple access points 24/7, and site-to-site physician/radiologist consultations, were also seen as key to the success of the PACS implementation.

The realization of a provincial PACS did not come without its challenges. From a clinical perspective, PACS resulted in a decrease in physician to radiologist consultations within a site, although this has been offset somewhat by an increase in consultations between sites. From the administrative side, PACS was very costly to implement and to maintain, making it difficult to justify PACS based solely on a financial costing model. The primary reasons for not achieving a return on investment for PACS in many sites was a combination of low exam volume, a pre-existing efficient film environment, and the high costs for PACS hardware, software and ongoing maintenance.

DEDICATION

To my wife Lorraine, and children Jared and Reghan;
Dad's finally finished school

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Introduction

1.1 Electronic Health Record (EHR) Initiatives: Canada and Newfoundland and Labrador

For this study, a benefits evaluation was carried out on the implementation of Picture Archiving and Communication Systems (PACS) in the province of Newfoundland and Labrador, recognizing that PACS is only one of several information systems that will ultimately encompass the provincial Electronic Health Record (EHR). Specifically, this research focused on the PACS implementation in the Western Health Authority of the province, with select components of the study design carried out in the Central and Eastern Authorities. While other information systems (e.g., Pharmacy, Telehealth, Laboratory) considered part of the EHR are out of scope for this evaluation, it is nevertheless important to understand how PACS fits in with the overall EHR implementation plan from both a national and provincial perspective, and the role that the Newfoundland and Labrador Centre for Health Information plays in implementing the provincial EHR.

Canada

An Electronic Health Record (EHR) is a virtual network linking major clinical and administrative information systems together to allow authorized health care providers secure access to a patient's key health history and care within the health system. In Canada, the federal government established Canada Health Infoway (Infoway) in 2001 to accelerate the development and adoption of the Electronic Health Record (EHR) in all provinces. Infoway was provided with $1.2 billion in funding and a 7-year mandate to work with all jurisdictions in Canada in both planning and implementing their EHR initiatives. A further $400 million was provided to Infoway in the 2007/08 Federal budget. Infoway's goal is to have 50% of Canadians connected to an EHR by the end of 2010.

In their 2003/04 Business Plan, Infoway identified six core components of an EHR: (1) unique personal provider/client registries, (2) pharmacy network, (3) laboratory network, (4) telehealth, 5) public health surveillance, and (6) diagnostic imaging. Each of these EHR components is briefly described:

1) ***Unique Personal Provider/Client Registries***

Registries are considered the foundation of any EHR solution. Clients and providers of the healthcare system, as well as locations where health services are provided, have to be accurately identified in order to achieve the full benefits of an EHR (Canada Health Infoway Infosheet – Registries http://www.infoway-nforoute.ca/Admin/Upload/Dev/Document/Infosheet_E_Reg_Final.pdf).

2) Drug Information Systems

Drug Information Systems (DIS) will allow access by authorized health professionals to a client's complete medication profile. By capturing all drugs and dosages prescribed, the DIS will provide physicians and pharmacists with accurate data that will support improved patient care. (Canada Health Infoway Infosheet – Drugs).

http://www.infoway-inforoute.ca/Admin/Upload/Dev/Document/Infosheet_E_Drug_Final.pdf

3) Laboratory Network

Having access to on-line laboratory test results will enhance decision-making and case management at the point of care. On-line access to laboratory results will reduce unnecessary duplicate tests and support quicker diagnosis and ultimately, improved patient care (Canada Health Infoway Infosheet – Labs).

http://www.infoway-inforoute.ca/Admin/Upload/Dev/Document/Infosheet_E_Lab_Final.pdf

4) Telehealth

Telehealth is the provision of health services through telecommunications technologies. Existing telehealth networks in Canada are already instrumental in bringing healthcare access to many remote and rural communities. Infoway's investment in telehealth has two goals: 1) to increase utilization and sustainability of existing telehealth networks, and 2) to encourage further expansion of telehealth programs into remote communities (Canada Health Infoway Infosheet – Telehealth).

http://www.infoway-inforoute.ca/Admin/Upload/Dev/Document/Infosheet_E_TH_Final.pdf

5) ***Public Health Surveillance***

The Public Health Surveillance Strategy will concentrate on the management of communicable diseases, major outbreaks and immunization programs. Once implemented, Public Health Surveillance will enhance the ability of jurisdictions to provide health alerts, as well as allow for the release of quality data and associated reports (Canada Health Infoway Infosheet – Public Health Surveillance).

http://www.infoway-inforoute.ca/Admin/Upload/Dev/Document/Infosheet_E_PH_Final.pdf

6) ***Diagnostic Imaging***

Infoway's Diagnostic Imaging (DI) Program envisions a system that will allow radiology images and reports to be shared by authorized health professionals in different locations across the country. This approach, referred to as a "shared services" approach, requires that a single DI repository be installed in one hospital which then serves as the "hub" for all healthcare facilities in the area. Authorized healthcare providers across the nation would be able to access this information, if necessary. (Canada Health Infoway Infosheet – Diagnostic Imaging).

http://www.infoway-inforoute.ca/Admin/Upload/Dev/Document/Infosheet_E_DI_Final.pdf

In addition to these six (6) core components of an EHR, Infoway is also investing in four additional strategic programs in Canada: 7) Interoperable EHR Systems, 8) Innovation and Adoption, 9) Infostructure, and 10) Patient Access to Quality Care:

7) Interoperable EHR Systems

Solutions that allow health professionals to view and update an integrated patient health record from anywhere, at any time.

http://www.infoway-inforoute.ca/Admin/Upload/Dev/Document/Infosheet_E_IEHR_Final.pdf

8) Innovation and Adoption

Projects that provide a catalyst for the implementation and adoption of electronic health record solutions in Canada.

http://www.infoway-inforoute.ca/Admin/Upload/Dev/Document/Infosheet_E_InnAd_Final.pdf

9) Infostructure

The development of common architectures and standards that support the interoperability of electronic health record solutions.

http://www.infoway-inforoute.ca/Admin/Upload/Dev/Document/Infosheet_E_Info_Final.pdf

10) Patient Access to Quality Care Program

The Patient Access to Quality Care (PAQC) investment program was established in the fall of 2007. This $50 million program is aimed at improving timely access to services across the continuum of care. It is expected that 5-8 projects will be funded across Canada in 2008, with the goal of reducing patient wait times via the use of technology in both clinical and administrative environments.

http://www.infoway-nforoute.ca/Admin/Upload/Dev/Document/EHRnews_Winter2008_EN.pdf

In their 2006/07 annual report, Canada Health Infoway reported that they had committed approximately $1.14 Billion out of their total budget of $1.266 Billion across the nine (9) program areas. (Canada Health Infoway Annual Report 2006/07). Partnerships with Infoway generally require investments by a jurisdiction of between 25%-50% of the eligible costs for any specific project.

Newfoundland and Labrador

In Newfoundland and Labrador, the Health System Information Task Force was established in 1993 by the Department of Health, the Newfoundland Hospital and Nursing Home Association, and Treasury Board. The Task Force was mandated to review the current provincial health information system, develop a vision that would reflect the concept of improved health through improved information, and make recommendations on how this vision could be realized. The final report of the Task Force was delivered to government in July 1995, and included 24 recommendations on how the province could improve health through improved information. The most important recommendation was for government to establish the Newfoundland and Labrador Centre for Health Information (NLCHI), with a mandate to deliver on the remaining twenty-three recommendations.

In October 1997, the Newfoundland and Labrador Centre for Health Information became operational. The Centre's vision is to improve the health and well-being of the people of Newfoundland and Labrador by making quality health information available to the public, health professionals, government, regional health authorities, and other organizations and agencies. The Centre also has the responsibility for the implementation and project management of a province-wide Health Information Network (HIN). The HIN will allow health professionals to electronically share information with each other.

As well as having the challenges all new organizations experience in starting up, NLCHI had the additional burden of delivering a Health Information Network with no funding; government approved the establishment of NLCHI on the condition that funding for the HIN be found within the existing health system funding envelope. In a province that had a history of failure with large technology projects, in addition to running consecutive budget deficits, NLCHI's mandate to deliver a HIN for the province appeared daunting.

The first task undertaken by NLCHI in 1997 was to consult with over 1,000 stakeholders in the province. These consultations were used to educate key stakeholders in the province on the vision of a provincial HIN, and to garner support for the provincial HIN vision. These consultations were completed in February 1998. At the same time the consultations were being conducted, NLCHI contracted with KPMG Consulting to prepare an *Information Systems Strategic Plan.* This plan was completed in March 1998 and confirmed that the vision developed by the Health System Information Task Force in 1995 was still valid. The Centre's original vision was guided by the principles that the HIN would be: a) secure, confidential and private, b) based on common standards, c) subscribe to the fundamentals of open system architecture, d) viewed as a strategic resource, and e) person centered.

In spite of the overwhelming support from the health system, and validation of NLCHI's vision by an external consulting group, there was still no substantive funding forthcoming from government for the HIN. Faced with this challenge, NLCHI's Board of Management approached government in April 1998 and received approval to develop a Benefits Driven Business Case (BDBC). Completed in October 1998, the BDBC presented government with an incremental approach to the implementation of the HIN, whereby the building of early phases of the HIN would provide savings to government. These savings could then be redirected at those areas of the HIN that did not provide financial savings, but were nevertheless critical to its overall success.

The BDBC presented government with an eight phase implementation plan for the provincial HIN. The sequence of implementation was as follows:

1. Unique Personal Identifier/Client Registry
2. Personal Medication Dispensing History (i.e., Component of Pharmacy Network)
3. Personal Diagnostic Service History (i.e. Diagnostic Imaging and Laboratory)
4. Diagnostic Service Requestor Decision Support
5. Personal Medication Regimen (i.e., Component of Pharmacy Network)
6. Personal Health Information Profile
7. Physician Practice Pattern Profiling
8. Clinician Decision Support Tools.

The BDBC recommended the implementation of the first two phases of the HIN: the Unique Personal Identifier/Client Registry and the Personal Medication Dispensing History (i.e., Pharmacy Network), given these two phases had the greatest potential for providing government with financial savings within the existing health system. Each of these initiatives is described in more detail below.

Unique Personal Identifier/Client Registry

The Unique Personal Identifier/Client Registry is a provincial information system for identifying patients and clients of the health system. It is a cross-referenced index of numbers (i.e. identifiers) assigned to individuals, including: insurance number, hospital number, file number, and computer generated numbers.

The BBDC identified significant potential savings from the introduction of a UPI/Client Registry because of its impact on the provincial health insurance system. The Newfoundland and Labrador population has always been mobile, as economic hardships forced residents to seek employment in other parts of Canada. However, the closure of the cod fishery in 1992 significantly increased the numbers of people leaving the province in search of work. A study completed by the Provincial Ministry of Health in 2002 reported that the province experienced a net loss of approximately 80,000 residents from 1982 – 1998 (Valvasori et al, 2001). The study suggested that approximately 40,000 of these residents continued to hold a valid provincial health insurance card, with a significant number (approximately 50%) continuing to present their Newfoundland insurance card when seeking services in their new province of residence. The study concluded that if the province was able to accurately track residents of the province, and identify former residents that have a valid health insurance card from Newfoundland and Labrador, the reciprocal billing program, used to pay for health services provided to residents outside the province, would be reduced by approximately $1.2 million annually.

In May 2000, nineteen months after the BDBC was originally submitted to government, approval was given to proceed with the implementation of the Newfoundland and Labrador Unique Personal Identifier/Client Registry. In May, 2002 the Client Registry was completed at a cost of approximately $3.5 million to the government of Newfoundland and Labrador.

In January 2003, NLCHI began a project to enhance the existing client Registry with $5.4 million in funding provided by Infoway. In the summer of 2005, NLCHI completed enhancements to the Client Registry. With Infoway's investment, the Newfoundland and Labrador Client Registry became what is known as a "Best of Breed" registry, and is now the accepted standard for EHR projects across Canada.

Personal Medication Dispensing History (i.e., Pharmacy Network)

A Personal Medication Dispensing History involves linking community and hospital pharmacies and physician offices, so that a patient's historical and current medication profile is available to health professionals at the point of care. The BDBC suggested that the Personal Medication Dispensing History would deliver savings to the health system by reducing adverse drug events (ADEs), both in the community and the hospital settings. With accurate real-time prescription profiles available, health professionals would be able to intervene before an adverse event occurs. Such interventions would reduce emergency room visits, hospital admissions and extended lengths of stay. The Personal Medication Dispensing History would also result in more appropriate prescribing and dispensing, recognition of contraindications, improved counseling, improved compliance monitoring and reduced abuse of prescription drugs. The BDBC identified approximately $4.1 million in annual savings to the health system following the implementation of the provincial Personal Medication Dispensing History.

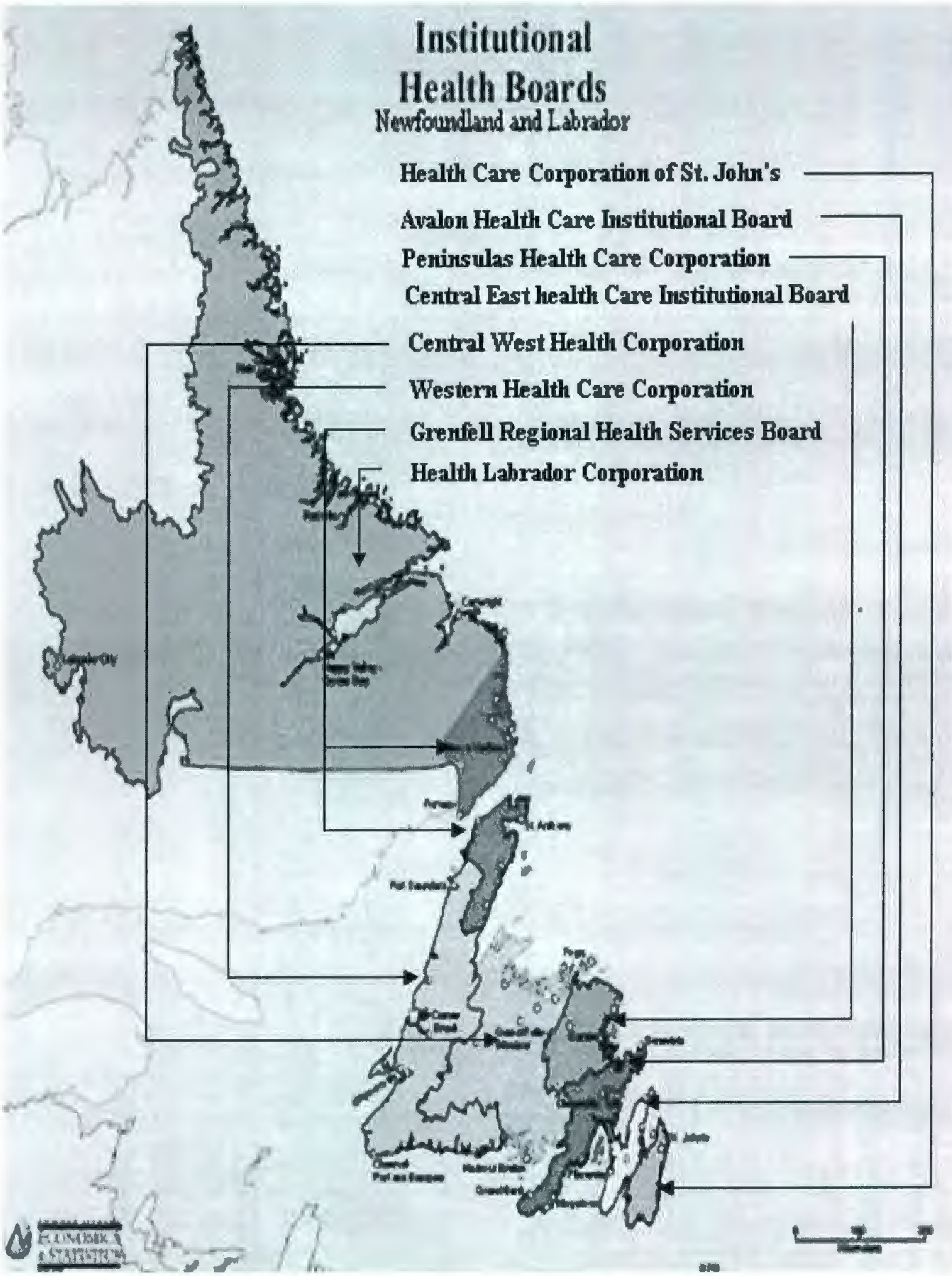
In May 2002 the provincial government gave approval to NLCHI to carry out a Pharmacy Network (i.e., Personal Medication Dispensing History) project scope. A project scope is a high level analysis that determines the required functionality of an information system, and the resources needed for its implementation. The project scope was completed and submitted to government in April 2003. This was followed by further dialogue and clarification, during which time government was provided additional information in support of the Pharmacy Network. In October, 2004 government approved NLCHI moving forward with issuing a Request for Proposals (RFP) for implementation of the Pharmacy Network. Following a lengthy process a preferred vendor was selected in June 2006 to work with NLCHI in implementing the Pharmacy Network. Also in June, the provincial government and Infoway signed an agreement to partner on the implementation. It is expected that the Newfoundland and Labrador Pharmacy Network will "go live" in early 2009.

1.2 History of Picture Archiving and Communication Systems (PACS)

Picture Archiving and Communication Systems (PACS) present an opportunity to radically change film-based radiology services both inside and outside the hospital setting. In the past, the usual medium for capturing, storing, retrieving and viewing radiology images was hard copy film. The idea to replace film with digital images was first conceptualized in 1979 (Huang 2002). However it was not until the early 1980s that advances in technology made introducing PACS into radiology departments feasible (Duerinckx, 2003). PACS replaces the film environment with an electronic means to communicate and share radiology images and associated reports in a seamless manner between health professionals.

Prior to the creation of Canada Health Infoway in 2001, PACS implementations in Canada were generally funded either by provincial governments, regional health authorities, or individual institutions (e.g., hospitals). During the period from 1998-2002, the province of Newfoundland and Labrador implemented PACS on a project basis across its eight (8) regional health authorities that existed until 2003 (Figure 1). In 1998, the Central East Health Region installed the first regional PACS in the province, and in 2001, the CHIPP/Tele-i4 initiative added PACS in four more regions: Avalon, Central West, Peninsulas, and the Janeway Hospital, which is located in the St. John's Region. In 2002 the Grenfell Health Region implemented PACS, and in early 2005 the Health Care Corporation of St. John's completed its PACS. Following the implementation of PACS at the Health Care Corporation of St. John's, approximately 70% of Newfoundland and Labrador service delivery areas had PACS capability, although these PACS were not inter-connected and could not communicate beyond the local installation.

Figure 1
Newfoundland and Labrador Health Boards (1994-2003)



There are also several jurisdictions in Canada that have, or will be implementing PACS, as a result of Infoway's Diagnostic Imaging Investment Program. These PACS have either been specific to one hospital, a group of hospitals (i.e., enterprise-wide), or implemented across a regional Health Authority (e.g., Fraser Health in British Columbia). Infoway reported that at the end of March 2007, they had partnered on 26 separate PACS initiatives across the 10 provinces and territories in Canada. Of these projects 8 had been completed, and 18 were ongoing (EHRnews@Infoway Newsletter, Summer Edition 2007).

www.infoway-inforoute.ca/Admin/Upload/Dev/Document/EHRNews_Summer%2007_EN.pdf

1.3 The Role of PACS in the Newfoundland and Labrador EHR Initiative

The province of Newfoundland and Labrador was well positioned in 2002 to be early beneficiaries of Infoway funding, given the province had been planning its own EHR since 1998.

In the fall of 2005, Infoway and the Newfoundland and Labrador government partnered on a $23 million initiative to implement the first *province-wide* PACS in Canada. This initiative had two overall objectives: (1) to implement PACS in selected rural sites where no PACS currently existed, and 2) to address gaps in those regions where PACS was currently operational.

As noted, PACS was operating in several regions for a number of years, although there were increasing concerns with the quality and capacity of image storage, the long-term sustainability of these systems, and their disaster recovery capabilities. Another concern was that some of the regions with existing PACS had yet to achieve a 95% filmless state, resulting in minimal savings (e.g., elimination of film costs). These reduced savings did not offset the initial or ongoing maintenance costs of PACS. Also, as a result of the project based approach for the implementation of these earlier PACS, there existed no provincial standards with respect to image referral or interoperability. These gaps needed to be addressed so that PACS would be able to integrate with the full provincial EHR.

The provincial vision for PACS was one that would provide access to: Any patient, Any image, Any report, Anywhere and Anytime (**A^5**). In realizing this vision, referring physicians and radiologists could view their patient's images and/or reports in a hospital, their office, or even in their homes.

With the Client Registry operational and the Pharmacy Network and PACS being implemented, the first three phases of the EHR in Newfoundland and Labrador originally envisioned by NLCHI in 1998, is expected to become a reality by the Spring of 2009. As of March 2008, NLCHI continues to work with Infoway on several other EHR partnership opportunities, including telehealth, laboratory and Interoperable EHR Systems (iEHR).

1.4 Research Questions

The key research questions for this study were:

1) Did PACS improve access (for patients) and increase efficiencies (for health professionals) that ultimately lead to enhanced patient care?

2) What are the perceived benefits of PACS from a user perspective, and did they change over time?

3) How do the benefits of PACS compare between rural and urban areas of the province?

4) What are the challenges in measuring the benefits of PACS in a province with a small population dispersed over a large geographical area?

1.5 Objectives of the Study

The objectives of the study were:

1. To validate and measure the benefits arising from the implementation of the provincial PACS (excluding Labrador) with a particular focus on:
   a) Improved accessibility to services for patients
   b) Improved quality of patient care
   c) Improved efficiencies of health care providers
   d) User satisfaction with PACS;

2. Where data is available, compare PACS benefit measures in Newfoundland with PACS benefits evaluations carried out in Nova Scotia, British Columbia and Ontario;

3. To describe the implementation of the provincial PACS within the context of other key strategies in the province (i.e., the Electronic Health Record (EHR) and the Electronic Medical Record (EMR);

4. To document the total cost of ownership of the provincial PACS and estimate the time to achieve a return on investment (ROI);

5. To identify and describe the key facilitators and barriers to a successful implementation of PACS;

6. To document the lessons learned from implementing PACS;

7. To document the challenges in carrying out a PACS benefit evaluation.

The research study is presented as follows. In Chapter 2, a literature review sets the stage by: (1) providing an overview of the various approaches currently used in evaluating the benefits of new technology; (2) summarizing previous PACS benefit evaluations; and (3) presenting a review of EHR benefit evaluation frameworks developed both at the national and provincial levels. Chapter 3 provides details on the various methodologies selected to maximize success in achieving the study objectives, while Chapter 4 presents a summary of the study results. A discussion of the results within the context of the study objectives is provided in Chapter 5, followed by a summary of the research findings and concluding remarks (Chapter 6).

Chapter 2
Literature Review

The literature review provides an overview of the following: (1) conceptual benefit evaluation frameworks, (2) various perspectives on how to approach benefit evaluations, (3) challenges faced when undertaking a benefit evaluation, (4) previous PACS evaluations, and (5) EHR benefit evaluation frameworks developed both at the national and provincial levels.

Authors Note: Sections 2.1 and 2.2 were derived from the report *Towards an Evaluation Framework for Electronic Health Records Initiatives: A Proposal For an Evaluation Framework (Neville, Gates, MacDonald et al, 2004)* for which the researcher was a co-author.

2.1 Conceptual Benefit Evaluation Frameworks

Several conceptual frameworks developed for guiding benefit evaluations of information systems have been published in the literature. These frameworks are diverse and can focus on one or more specific areas of evaluation (e.g., indicator measurement/selection, methodologies, processes, etc.).

Information Systems (IS) Success Model

Perhaps the most widely known framework developed for guiding benefit evaluations of information systems is the Delone and McLean Information Systems (IS) Success Model (Delone and McLean 1992). The authors put forward six (6) major dimensions of measurement: 1) system quality, 2) information quality, 3) use, 4) user satisfaction, 5) individual impact, and 6) organizational impact. Each is described briefly below.

System quality measures: engineering-oriented characteristics of the systems, such as response time, ease of use, system reliability, system accessibility, system flexibility and system integration.

Information quality measures: includes perceptions of information accuracy, timeliness, completeness, reliability, conciseness, and relevance, addressed mostly from the perspective of the user (subjective measures).

Measures of information use: includes use by whom, frequency of use and extent of use; valid only if system use is not mandatory.

Measures of user satisfaction: subjective measures, addressed mostly from the perspective of the user.

Individual impact measures: measures of performance, such as quality of decision making, change in decision behavior, time efficiency of task accomplishment, and time to (and confidence in) decision making.

Measures of organizational impact: employed mainly in the business sector and includes measures of cost reduction, cost effectiveness, contribution to profitability and return on investment (ROI).

The authors emphasize that it is important to study the interrelationships among these dimensions, to avoid arbitrarily selecting items from among the dimensions, and to combine measures from dimensions to create a comprehensive measurement instrument. Furthermore, they suggest that the selection of measures should consider contingency variables, such as the independent variables being researched, the size, structure, strategy and environment of the organization being studied, and the characteristics of the system itself.

In 2003, DeLone and McLean published a ten-year follow-up to their original IS Success Model article (DeLone and McLean, 2003), in which they looked back on how their model was applied, and whether it was validated or challenged by researchers over the last decade. The authors also put forward several refinements to their original framework including: (1) adding a third dimension, "service quality" to the two original system characteristics, "system quality" and "information quality", (2) substituting "intention to use" for "use" as a measure of system usage, and (3) combining the "individual impact" and "system impact" variables into a "net benefits" variable.

Social Interactionist Models

Bonnie Kaplan at the Center for Medical Informatics (Yale University School of Medicine) puts forward the social interactionist model (Kaplan 1997, 1998). This model is grounded on the interactions between individuals, systems and organizational characteristics, and considers not only the impact of the information system on the organization, but also the impact of the organization on the information system. Measures of benefits within the interactionist framework are categorized with the "4 C's": *Communication* (i.e., what are the anticipated long term impacts on the ways that departments linked by computers interact with each other?), *Care* (i.e., what are the anticipated long term effects on the delivery of medical care?), *Control* (i.e., will system implementation have an impact on control in the organization?), and *Context* (i.e., to what extent do medical information systems have impacts that depend on the practice setting in which they are implemented?). Kaplan proposed five methodological guidelines for developing a comprehensive evaluation framework: (1) focus on a variety of technical, economic and organizational concerns, (2) use multiple methods, (3) be modifiable, (4) be longitudinal, and (5) be both formative and summative (Kaplan 1997).

Cognitive Evaluation Approaches

Cognitive evaluation approaches employ a variety of methods including scientific, simulations, and naturalistic approaches. Kushniruk, Patel and Cimino (1997) identified the need for improved methodologies for the assessment of health information systems and their user interfaces, noting conventional methods of evaluation (e.g., interviews and surveys) rely on the user's memory, which may be quite different from their actual behavior. Methodologies which can be applied in the study of health information systems in both the laboratory and real life settings include:

> <u>Usability Testing</u> – evaluation of information systems involving subjects who are representative of the target user population:
>
> <u>Cognitive Task Analysis</u> – characterization of the decision-making and reasoning skills of subjects as they perform activities involving the processing of complex information; and

Computer Supported Video Analysis – video recording of subjects as they interact with user interfaces in carrying out specific tasks.

Kushniruk et al (1997) reported that while cognitively-based usability testing can be applied throughout the lifecycle of information systems, their experience to date has found that the greatest benefits come from formative analysis work. Kushniruk (2002) suggests that future evaluation efforts with health information systems should integrate approaches which examine process variables and address measurement of outcomes.

Project Review and Objective Evaluation for Electronic Patient and Health Records Projects (PROBE)

The PROBE report, prepared by the National Health Service (NHS) in the UK, describes a practical approach for the evaluation of Electronic Patient and Health Records. PROBE identifies four (4) core standards for an evaluation study which need to be considered throughout the planning continuum: utility, feasibility, propriety and accuracy. The key principles of evaluation emphasized are the need for both formative and summative approaches, advance planning, close integration to the project lifecycle, clearly defined aims and objectives, the inclusion of a before and after element, and the use of quantitative and qualitative data. Six steps are proposed when planning an evaluation: (1) agree why an evaluation is needed, (2) agree when to evaluate, (3) agree what to evaluate, (4) agree how to evaluate, (5) analyze and report, and (6) assess recommendations and decide on actions.

Total Quality Management (TQM)

Drazen and Little (1992) argue that new approaches are needed to evaluate health information systems in order to measure benefits that are important to the institutional sponsors. Enhancements to the traditional approach to evaluation include: (1) measuring benefits beyond cost savings, (2) focusing on critical issues and using standard tools to achieve efficiencies, (i.e. measure what is important, not what is easy to measure), (3) maintaining independence, given the involvement of the private sector in many of the evaluation initiatives, and (4) fitting with the institutional philosophy.

Total Evaluation and Acceptance Methodology (TEAM)

The TEAM evaluation approach (Grant et al, 2002) for information systems is based on a three dimensional framework: Role, Time and Structure. The *role dimension* identifies four main categories: designers, specialist users, end users and stakeholders. The *time dimension* has four main phases throughout the continuum of information system development: design, prototyping and testing;

evaluating prototyping of the system; evaluation after a maturing period; and ongoing periodic evaluation. The *structural dimension* distinguishes strategic, tactical or organizational, and operational levels. Key characteristics of this methodology include the insistence on a global rather than partial approach to the evaluation, and the recognition of the dynamic nature of information systems.

Health Technology Assessment

Kazanjian and Green (2002) propose a Health Technology Assessment framework as a conceptual tool for decision-making specific to health technologies. Impacts are considered at the societal level and from the perspective of patients as primary stakeholders. The framework dimensions include: (1) population at risk, (2) population impact, (3) economic concerns, (4) social context, and (5) technology assessment information.

Framework for Action Research

Action research gives emphasis to doing research with and for people, as opposed to on people. The goal is to create knowledge about a social system and then, as part of the research process, use this knowledge to change the system (Meyers, 2001). Action research has been used in social sciences since the 1940s, however it is generally not employed for evaluating information systems (Lau 1999). Lau put forward four dimensions of an evaluation: (1) a conceptual foundation, (2) a study design to describe the methodological details, (3) the research process of diagnosis, actions, reflections and general lessons, and (4) the respective roles of the researcher and participants. Four main role categories are identified: (1) those involved in the conception and design of the information system, (2) those who are responsible for the implementation and functioning of the system (specialist user), (3) those who use the system, and (4) those who have a vested interest that the information system is a success. There is a requirement for consensus of evaluation priorities from all stakeholder perspectives and a recognition of the limitations of an evaluation process so that the evaluation is considered both valid and achievable.

Balanced Score Card

The balanced scorecard (BSC) is a means to evaluate corporate performance from four different perspectives: the financial perspective, the internal business process perspective, the customer perspective, and the learning and growth perspective (Kaplan and Norton, 1992). Investments in health information systems are costly and it is necessary to quantify the success of such systems and the degree to which the investment was justified (Protti, 2002). Challenges to addressing these concerns include: (1) efficiency (doing things right) is easier to measure than effectiveness (doing the right thing), (2) new systems are intended to change difficult to measure actions, (3) strategic systems elude measurement, and (4) infrastructure investments can not be justified on a Return on Investment (ROI) basis.

2.2 Evaluation Perspectives

Perhaps the most widely known approach used in health related research is the Randomized Control Trial (RCT). An RCT is a scientific approach used in the testing of the efficacy of medicines or medical procedures. It is widely considered the most reliable form of scientific evidence because it eliminates many of the biases that often are unavoidable in approaches commonly used in benefit evaluations. However, the use of RCT's in evaluating the benefits of health technology is impractical, given the problems with randomization (Heathfield et al, 1997; Heathfield et al, 1999; Burkle et al, 2001), blinding (Burkle et al, 2001), costs (Moehr 2002; Heathfield et al, 1998), and sample size (Burkle et al, 2001; Moehr 2002).

Deciding on the evaluation approach to take will be influenced by a number of factors, including the individual disciplines comprising the research team and the trade offs between the options available (Heathfield et al, 1999). A summary of various perspectives on evaluation approaches used in health technology is provided:

Objectivist versus Subjectivist

Friedman and Wyatt (1997) first put forward the objectivist versus subjectivist perspective. The objectivist researcher: (1) is in agreement as to which dimensions of a system are important to measure, (2) believes that a "gold standard" exists that can be compared against a standard measure, and (3) believe that benefits of the system can be measured using quantitative methods. The subjectivist researcher feels that: (1) there are differing views on what is important to measure, (2) there is no "gold standard" for which to compare to, and (3) qualitative methods are used to understand the different opinions and conclusions reached by different observers in the same setting.

Formative Versus Summative

Formative evaluation occurs while a system is still under development and findings can be used to modify the system prior to completing the implementation. The role of the researcher is to provide results to those involved in the evaluation in order to inform ongoing program planning, development and refinement. Summative evaluations occur after a system has been implemented and are used to determine what has been achieved as a result of the program (Ammenwerth et al, 2003). These results could include outcomes and impacts, attainment of goals, unanticipated consequences, and possibly comparisons with alternative programs in terms of efficiency and effectiveness.

Scientific Versus Pragmatic

Scientific studies are designed to meet a set of standards set out by peers in their field and the value of their work is judged against these standards (Rossi and Freeman, 1993). Evaluation methods are ranked according to their ability to link cause and effect while controlling for both internal and external validity. The randomized clinical trial (RCT), which was previously discussed, is considered to be the "gold standard" method for scientific research (Cook and Campbell, 1979). The "pragmatic" evaluation recognizes that while scientific investigations and evaluation efforts may use the same procedures, the intent of pragmatic evaluations is to (a) produce maximally useful evidence within the specified budget and time (Cronbach, 1982) and (b) address the interests of the sponsors and other key stakeholders (Rossi and Freeman, 1993).

Accountability, Developmental and Knowledge Perspectives

Heathfield and Pitty (1998) proposed three (3) separate categories of perspectives with respect to evaluations: accountability, developmental, and knowledge.

Accountability perspective: to answer the question about whether a particular intervention caused a particular outcome. Such an approach usually involves the use of summative and quantitative methods.

Developmental perspective: to strengthen institutions, improve agency performance or help managers with their planning, evaluating and reporting of tasks. Usually involves formative evaluation methods and is often qualitative, but can be quantitative.

Knowledge perspective: to acquire a more profound understanding of some specific field. Depending on the academic discipline of the researcher involved, it can employ both qualitative and quantitative methods.

2.3 Challenges to Evaluation of EHR Initiatives

An extensive review of the literature did not locate any studies which evaluated the benefits of a comprehensive EHR. A comprehensive EHR is one that spans multiple systems across geographically dispersed service areas. Most studies that investigated the benefits of health information system implementation were of limited scope, in that they focused on small scale initiatives, such as when new technologies replaced existing administrative (usually paper-based) systems (Chaudhry et al, 2006; Heathfield et al, 1997), or when a study investigated at most two components of an EHR, such as the interface between pharmacy and laboratory systems (Ammenwerth, 2003). The settings for evaluations were also limited, in that most were carried out within a single hospital department, or focused on a specific hospital to physician office communication link (e.g., accessing lab results).

A possible explanation for this gap in the literature is that there are limited comprehensive EHRs implemented worldwide to evaluate. Historically, a lack of interest by government decision makers (i.e., funders) in establishing EHRs as a fixture in the management and delivery of health services significantly slowed their implementation. If governments do not consider EHRs a strategic investment, difficulties in evaluating the impact of such initiatives will be compounded by the lack of progress in their implementation (Healthfield and

Buchan, 1996). This has resulted in an interesting paradox; governments require evidence to support the investment of millions of dollars in EHRs, yet without implementing the systems and evaluating its benefits, researchers cannot deliver on the evidence needed by governments to support funding for their implementation (Healthfield 1999). A second possibility for the lack of evidence, although difficult to substantiate, is that comprehensive EHR studies may have been undertaken, but because they were not successful, they were not published (Healthfield, Pitty and Hanka, 1998; Tierney and McDonald, 1996).

Defining an EHR

Compounding the issue of having relatively few fully functional EHRs to evaluate, is the diversity in definitions of an EHR (Ash and Bates. 2005; Heathfield et al, 1999). To illustrate this divergence in EHR definitions. a summary of four major national EHRs strategies (i.e., United Kingdom, Australia, United States, and Canada) that have been, or currently are being, implemented is provided:

United Kingdom

The National Health Service (NHS) *Connecting for Health* initiative is an agency of the Department of Health in the United Kingdom and is responsible for incorporating new information technologies into the various health regions. The *Connecting for Health* initiative includes the following components of an EHR: 1) Electronic Scheduling, 2) Computerized Physician Order Entry, 3) PACS, 4) secure e-mail system, and 5) Quality Management and Analysis System. By 2010, the National Programme for IT estimates connectivity in England of over 30,000 GPs and almost 300 hospitals. (http://www.connectingforhealth.nhs.uk/publications/its_coming_leaflet.pdf).

Australia

Australia's EHR initiative is being implemented under the Health*Connect* initiative and is considered a virtual network, in that it utilizes change management strategies that support the communication of health information in an electronically shared health system. Health*Connect* encourages individual health information to be collected in a standard electronic format at the point of care, such as a hospital or doctor's office. An event summary at these points of care is then generated and could include information on the patient intervention including treatments, discharge summaries, test results, and prescribed medications.
(http://www.health.gov.au/internet/hconnect/publishing.nsf/Content/faqs-1lp#6)

Veterans Health Administration (United States)

The Veterans Health Administration (VHA) is the largest integrated health system in the United States and provides medical, prescription, surgical, and rehabilitative care for US veterans. The VHA EHR initiative consists of a computerized patient record system (CPRS) which is fully operational at all medical centers and most other VA sites of care. The CPRS provides access to online patient records that integrates medical chart information with various medical images such as x-rays, scanned documents, and exam results (Prelin et al, 2004).

Canada

In Canada, the national EHR initiative is the responsibility of *Canada Health Infoway* (Infoway), which is funded by the federal government. In 2002, Infoway described the functionality (or domains) of an EHR to include a: (1) unique provider/client registries, (2) pharmacy network, (3) laboratory network, and (4) diagnostic imaging. In 2003, two additional domains were included: 5) telehealth and 6) public health surveillance. Given all 13 jurisdictions in Canada are at different levels of EHR implementation with respect to these domains, Infoway is currently focused on implementation at the jurisdictional level. As jurisdictions continue to make advances with implementation, efforts by Infoway will begin focusing on linking individual (jurisdictional) EHRs towards the creation of a pan-Canadian EHR. The responsibility of linking the domains within jurisdictions, and across jurisdictions, will fall to Infoway's *Interoperable Electronic Health Record (iEHR) Strategic Program.* While it is premature for Infoway to commit to a timeframe for realizing a national EHR, the first jurisdiction in Canada expected to have a fully functional EHR is Newfoundland and Labrador, which is anticipated by 2011.

Lack of an EHR Evaluation Framework

Without broad consensus on what constitutes an EHR, it is not surprising that there currently is no standard evaluation framework to guide research into its benefits (Green and Moehr, 2000). Researchers, clinicians and decision makers have little evidence to draw from which can substantiate claims touting the benefits of an EHR (Healthfield, Pitty and Hanka, 1998; Mitchell and Sullivan, 2001; Donaldson 1996; Kazanjian and Green, 2002). Researchers are further disadvantaged given the limited opportunities to compare their results with previous evaluations. Such comparisons could identify best practices, facilitators and barriers to success, and lessons learned (Campbell et al, 2000).

Complexity

No two EHR implementation processes, both from a technical and functional perspective, are alike (Keen et al, 1995; Healthfield, 1999; Middleton et al, 2005). Depending on the audience (e.g., clinical, administrative or political), the complexity of these systems can generate a myriad of very different research questions, and it is difficult to decide which ones are the most important to address within the resources available (Burkle et al, 2001). In addition, as the number of systems included in the evaluation increases so too does the complexity of the study design. However, the more complex the evaluation, the more costly it is to evaluate. (Campbell et al, 2000; Ammenwerth, 2003).

Advances in Technology

Advances in technology are generally felt to benefit society as a whole. However, when these advances occur over a relatively short period of time (e.g., 2-3 years) the impact on an EHR evaluation can be very detrimental. For example, it would be normal for a systems evaluation using a pre/post comparative design to take 2-3 years to complete. Over this period the technology being evaluated could be upgraded, modified or replaced by new technology, making the original study design redundant. Also the implementation of information systems is usually implemented in phases; rarely is a system completely installed before the "switch is turned on". As various components of the system are installed through different phases, systems installed in later phases may impact those installed in earlier phases. This will create problems for the evaluation, given data collected in earlier phases may no longer be valid (Keen, 1999).

2.4 Previous Evaluations of PACS Initiatives

Although PACS installations began to show up in the early 1980's, in most cases these systems were installed in a single radiology department (or image centre), with no electronic sharing of images or reports outside the radiology department (Bryan et al, 1995). As installations matured, other hospital departments outside radiology were connected to PACS (e.g., emergency departments). This was followed by multiple hospitals being connected to a single PACS repository. With this enhanced connectivity, radiology images and reports could now be shared among authorized health professionals beyond the radiology department where the patient received services. This provided three main advantages: 1) within a hospital, physicians no longer needed to travel to the radiology department or film library to review a patient's film or report, 2) historical exams/reports could be easily accessed, and 3) an image generated in a site not having a radiologist on staff could be sent to another site for interpretation. At the second site the radiologist could interpret the exam and post the report on the shared PACS for the referring physician at the originating site to access.

In evaluating the benefits of PACS there are many approaches and methodologies that can be employed. The approaches described previously (e.g., formative versus summative, subjective versus objective) are different perspectives on how best one can measure specific benefits. When reviewing the literature on PACS evaluations, it was rare that the author actually stated the approach taken in terms of evaluation perspectives. One must review the methodology closely to determine if, for example, the approach utilized was formative or summative. In the majority of papers, the methods section is limited to identifying the specific methods of data collection (e.g., surveys). In reviewing the literature, the methods most often used in evaluating PACS were: 1) questionnaires/surveys, 2) data collection sheets, 3) administrative data/project documents, 4) time and motion studies, 5) direct observation, 6) video recording, and 7) interviews.

Within this context, a review of studies undertaken to evaluate the benefits of PACS, and the methods used, is presented. The review is organized according to the environment in which PACS was evaluated; private clinic, radiology department, or departments outside radiology.

<u>Private Clinic</u>

A cross-sectional descriptive study by Colin et al (1998) surveyed 30 radiologists to determine the benefits of implementing PACS in a private clinic. A questionnaire was administered in 1993, one year after the conversion of film to PACS, with 20 of the 30 (67%) radiologists responding. The survey found that the degree of perceived benefit of digital radiography varied, depending on the type of exam under study; vascular procedures were rated highest, whereas chest x-rays were rated lowest. In addition to the survey, data collection sheets filled out by radiology technologists reported that PACS generally reduced waiting times, while a separate analysis of administrative data did not find evidence of cost savings resulting from PACS.

Chan et al (2002) also used a combination of questionnaires, data collection sheets and administrative data to study the implementation of PACS in a private clinic. Referring physicians and radiologists both perceived PACS superior to film, while radiology technologist productivity increased from 30%-58% depending on the exam type. Savings were identified as a result of reduced film and processing costs.

Reiner et al (2002) used a time and motion study at three medical centres to compare the time it took to complete chest and spine exams (i.e., from when a patient arrived in the examination room to when the exam was ready for interpretation by the radiologist). Conventional film was used at two of the centres, whereas PACS was used at the third. Combining the average time for both film centres, a time savings of 5.1 minutes (41%) was found with PACS for chest exams and 10.3 minutes (54%) for spine exams.

Radiology Department

Using a quasi-experimental approach, Kato et al (1995) compared the total time in the radiology department for a radiologist to interpret an exam in a film versus a PACS environment. In Japan, at the time of the study, law required that hard copy film be retained even though a PACS system was operational. Time was recorded for interpreting each type of exam by two radiologists independently, one on film and one on PACS. Exams under study were computed radiography (CR), computed tomography (CT) and magnetic resonance imaging (MRI). The results indicated there was no significant difference in interpretation time (in minutes) between film and PACS across these three modalities (CR: 279 versus 273; CT: 345 versus 343; MRI: 452 versus 530).

A time and motion study carried out by Langlois et al (1998) compared the utilization of PACS and film in a radiology department. The authors concluded that there were no significant differences in the time needed to generate an exam between film and PACS for both chest and orthopedic exams. This outcome was felt to be the result of the film environment already being efficient prior to implementing PACS.

Reiner et al (2001) used a time and motion study to compare radiologist productivity in a radiology department in a film environment versus PACS. Four radiologists interpreted 100 randomly selected CT scans using both hard copy film and digital images produced by PACS. A 16.2% reduction in time to interpret the CT exam was found with PACS in comparison to film.

A study by Bryan et al (1998) used direct observation to determine the total time required for radiologists to complete a report in a radiology department. Data were collected over four time periods: two using conventional film, one using hard copy computed radiography and one using digital images. The study concluded there was no significant difference in reporting times between the four data collection periods, although more historical images were accessed in PACS than in the film environment.

Using a unique approach, Siegel et al (2000) surveyed radiologists in seven sites around the world to determine their satisfaction with their current reading room environments. The attributes considered the most important in improving a radiologist's productivity were lighting, number of monitors and monitor brightness. Recommended improvements included reading room layout, temperature controls and noise.

Rumreich and Johnson (2003) carried out a survey of radiologists to determine the satisfaction with their current PACS image reading environment. The survey was sent electronically to 90 potential respondents, with 55 responding (61%). Using a five-point likert scale (1 = very dissatisfied and 5 = very satisfied), the study found that the most important attributes that existed in their reading room environment were "reading room close to rest room (3.47)", "reading room close to entrance/exit (3.36)", "having access to dictation (3.06)" and "appropriate lighting (2.86)". Those areas found to be lacking were "workspace ergonomics (2.23)", "room layout (2.35)", "amount of workspace (2.48)" and "noise level (2.5)".

Horii et al (1994) used data collected directly from the PACS to study the utilization distribution of various functions. Functions most frequently used were brightness and contrast. Of interest, junior physicians (i.e., residents and interns) were more likely to log on to the PACS workstation (67%) than attending physicians and fellows (8.9%).

An early study of a neuroradiology PACS installed in a radiology department was carried out by Lou and Huang (1992). This study used administrative data and surveys and found that PACS saved radiologists' time and allowed more efficient retrieval of archived exams.

Sacco et al (2002) carried out a cost/benefit analysis on the implementation of a PACS in a radiology department at the University of Siena, Italy. Total costs for the PACS included operator costs, and costs for film, paper, chemicals and rent. The authors concluded that cost savings from the elimination of film and chemicals were offset by the equipment costs for PACS.

Reiner et al (2002) compared the diagnostic accuracy of radiologists in interpreting CT scans using PACS versus film. Four radiologists interpreted 117 CT scans both on film and on digital image. Using a unique method to reduce bias, the images were reviewed in a manner that the image was used only twice, once with film and once with digital, and that no one radiologist interpreted the same exam twice. In interpreting brain CT scans there was no difference in sensitivity between PACS and film, although PACS was found to improve specificity, accuracy and the false positive ratio. In interpreting chest and abdominal CT scans combined, PACS was found to have improved sensitivity compared with film. There was no difference between PACS and film when comparing abdominal and pelvic CT scans.

Departments Outside Radiology

Physicians in an Intensive Care Unit (ICU) can provide enhanced patient care if they have immediate access to radiology exams. Prior to the implementation of

PACS, the only way for an ICU physician to review images and/or reports was for the radiology department to deliver the hard copy film to the unit, or for the physician to review the film in the radiology department. Ravin (1990) found that by introducing PACS into the ICU, physicians were no longer required to walk to the radiology department to view the image, a savings of approximately 20 minutes. The study also noted that a disadvantage to PACS in the ICU was the potential to reduce consultations between the radiologist and the ICU physician.

An earlier study carried out in ICU by Kundel et al (1991) looked at the physician's utilization of a PACS work station versus film. This study took place over a 12 month period, during which time there was an 8 week transition period from film to PACS. A total of 58 physicians in intensive care provided data by completing a "consultation" form when the image was requested, and an "action" form when the image and/or report was first available for clinical purposes. The study found that the majority of physicians (65%) preferred viewing film as opposed to digital images. The authors hypothesized that the preference for viewing film was the result of physicians not having confidence in the accuracy of digital images.

Andriole et al (1996) carried out a study of PACS in an ICU using a video camera mounted in the reading room, as well as patient charts and time sheets. The authors found that the time from exam completion to time the referring physician reviewed the exam was reduced from an average of 150 minutes in the film environment to 90 minutes following the implementation of PACS.

Reiner et al (1996) used surveys and one-on-one interviews to study the benefits of PACS versus film in a vascular surgery department. Data was collected 2 ½ years after PACS was installed, with seven physicians and eight nurses in the vascular surgery department completing a questionnaire, followed-up by individual interviews. The measures of PACS (when compared to film) most strongly supported by physicians were the increase in information available, image availability, image quality and quality of patient care. In comparison, nurses rated image review in the operating room, image retrieval and quality, and image availability superior in PACS when compared to a film environment.

Williams et al (1997) carried out a study in a nuclear medicine department to determine the impact that PACS had on the department with respect to functionality and efficiency. Using data collection sheets, physicians were asked to answer three questions for each of 250 consecutive non-cardiac nuclear medicine images. A summary of the questions asked were: 1) was PACS used in the exam interpretation? 2) did PACS expedite completion or interpretation of the exam?, and 3) did PACS permit a final diagnosis? In 155 (62%) of the exams in which PACS was used, 86 (55%) of theses exams were perceived by the physicians to be completed in a shorter time period with PACS than with film.

Bone scans made up 102 of the 155 exams where PACS were used. Of these 102 exams, physicians felt PACS aided in the interpretation of 66 (65%) of the exams, expedited exam completion in 25 (25%), and provided a final diagnosis in 32 (31%).

Redfern et al (2000) employed a time and motion study pre and post PACS in the radiology department and three other clinical areas. The study found an increase in the interval time from 20 to 25 minutes from the time of the request, to the time the exam was ready for viewing in the emergency department following the implementation of PACS; however the interval time from image availability to report being available was shortened from 38 to 23 minutes. The study also found that the increased time to report availability was directly related to increased patient volumes.

Watkins et al (2000) studied the impact of PACS on image availability and patient care in ICU. Data was collected by both clinicians and radiologists on various data collection sheets, and were collected over three time periods: two before the implementation of PACS and once following implementation. A second pre PACS data collection period was carried out to take into account the re-location of the film dark room following the first data collection period. Data collected at each of the three periods included: time of request, time of exposure, exam availability and time for clinical action. The average time (in minutes) from time of exposure to the time the exam was available increased from period 1 (37) to period 2 (48), but decreased after PACS was installed in period 3 (19). There was no significant difference found between the PACS and film environment with respect to the time interval for clinical action.

Cox and Dawe (2002) investigated the benefits of PACS in an ICU using questionnaires, interviews and process analysis. The study found that 94% of ICU staff felt that overall services had improved, while 90% felt that images were available more quickly than in the film environment. Of interest was that 80% of referring physicians felt that clinical decisions were made quicker in the PACS environment than that of film, whereas only 60% of radiologists thought this was the case.

A study by Andriole (2002) compared workflow, productivity, speed and costs for chest x-rays in an outpatient department for digital, computed radiography and film exams. Using times sheets, surveys and administrative data, the study found that technologists perceived digital exams improved workflow, were easier to use and more reliable. Digital exams were also found to decrease the time from image ordering to exam availability for interpretation compared to computed radiography and film (5.7 minutes versus 6.7 and 29.2 respectively). The study concluded that the high cost of digital images may not be justified in a low volume radiology department.

Redfern et al (2002) used a time and motion study to investigate the time it took for a technologist to produce the radiographic image in an emergency department after switching from film to PACS. Using multiple least squares regression, the authors estimated that there was a 2 minute reduction in the time required to produce the image in PACS compared to the film environment. The authors reported that the reduction was most likely due to the removal of steps required in handling the film, and the elimination of quality control processes inherent in creating a hard copy film image.

Other Areas of PACS Evaluations

Many PACS evaluations published in the literature are not specific to a setting, rather they are specific to an issue related to PACS. These include evaluations that investigated financial benefits, pre-implementation planning, system integration, image quality, integration of voice recognition, and technical issues.

Financial Benefits

Financial benefits that can be realized through the implementation of PACS fall into two areas; cost savings and increased revenues. Cost savings are achieved through the elimination (or reduction) of ongoing expenses related to the film environment, and are a direct result of the implementation of PACS. With respect to increased revenues, the majority of this research comes out of the United States of America (USA). The American health system in the USA is a user pay model. If efficiencies are achieved with PACS over hard copy film additional revenues result for the institution if the number of patients receiving radiology services is increased (i.e., increased patient throughput).

Cost Savings

Cost savings (sometimes referred to as cost avoidance) are achieved through the elimination of costs associated with transporting film, reducing staff levels needed for maintaining the hard copy film library (Huang 2003), eliminating cost for chemicals and film (Huang 2003), eliminating transportation costs (Strickland 2000; Maass 2001; Chan 2002; Huang 2003), and freeing up space historically used to house hard copy film (Grosskopf 1998; Terae 1998; Cartier 1999; Strickland 2000; Maass 2001; Chan 2002; Huang, 2003).

Increased Revenues

Where hospitals and image centres are paid for each radiology service provided to a patient, PACS can provide an opportunity to increase revenues. This is made possible when radiologists become more efficient in reviewing digital exams (images) and preparing reports for referring physicians. With this increased efficiency, hospitals can accommodate more new patients (i.e., increase productivity) from their pool of referring physicians (Chopra 2000; Kim 2002; Andriole 2002; Hunt 1998; Reed 1996). In Canada, delivery of health services is financed through the Canada Health Transfer (CST), which provides universal health care insurance to all residents of Canada. The CST is conditional and must be spent on health. Legislation such as the Canada Health Act specify standards that the provinces must maintain in order to receive CST funding. Therefore, PACS provides limited opportunity for hospitals in Canada to generate revenues by increasing the number of patients seeking radiology services. Although it can be argued that increased volumes results in enhanced patient care, which can translate into increased funding.

Pre-implementation planning

Planning for the implementation of PACS has drawn considerable interest from the research community in recent years. Pre-implementation planning studies have various degrees of scope, ranging from looking at the complete process, to carrying out a gap analysis and developing a Request for Proposals (RFP), to selecting the vendor (Ortiz 2002; Swaton 2002; Lepanto 2002; Farnsworth 2003; Bedel and Zdanowicz 2004; Lawrence 2005). Other implementation studies are even more specific, such as studies that investigate the role of a PACS Committee (Reed 2001), the value of marketing PACS to end-users (Viau 2004), the challenge in linking PACS to external clinics (Arreola 2003), and the degree of implementation of PACS in other countries (Foord 2001; Inamura 2001; Burbridge and Bell 2004).

System Integration

The maximum benefit of PACS is achieved when it is integrated into both the Hospital Information System (HIS) and the Radiology Information System (RIS) (Carrino 1998; Reiner et al, 2002; Seigel and Reiner, 2003). A basic PACS architecture generally starts at the HIS, as this is where patient demographic information is held, and in most cases, where the service order originates. Both patient demographic and order information is sent from the HIS to the RIS, which distributes this information to the appropriate modality in the Radiology Department (e.g., Chest X-Ray). Once the image is created, it is sent from the RIS to the PACS for reviewing by the radiologist, who can then append the image report to the PACS (Mulvaney 2002). In many cases separate "broker" software is required so that the computer language (Health Level 7- HL7) used in the RIS is compatible with the language (Digital Imaging and Communications in Medicine - DICOM) used in PACS (Boochever 2004). DICOM is a standard that supports the connectivity of digital imaging devices, whereas HL7 messaging allows medical devices to interact and exchange information.

The benefits of PACS integration into the RIS and HIS systems include the elimination of redundant data entry, the availability of more accurate information in PACS, and a reduction in workload for radiology and clerical staff (Levine et al, 2003).

Image Quality

An increase in productivity and a reduction in costs are only beneficial if there is no loss of image quality when compared with traditional film. Given the massive amounts of computer memory (storage) required to store, transfer and retrieve digital images, earlier versions of PACS were disadvantaged simply because they were too expensive to operate (Agarwal, 2003; Erickson, 2002). A relatively recent solution to the large amounts of space needed for digital imaging is to compress (or shrink) the image so that it does not require as much space for storage/transfer. Two types of compression are used: Lossless (reversible) and Lossy (irreversible) compression; both have advantages and disadvantages. Lossless compression provides a digital image that is a near perfect re-construction of the original, however the ratio of compression achieved is only in the range of 2:1 to 4:1. Lossy compression on the other hand can reduce the image by arbitrarily large ratios, but at a loss of image quality (Erickson, 2002).

Integration of Voice Recognition

The installation of a voice recognition system that interfaces with PACS has been found to reduce the percentage of lost or unreported examinations (Hayt, 2001) and improve report turnaround time (Azevedo-Marques et al, 2004). Voice recognition technology allows the radiologist to dictate an oral report via the voice recognition system, which is then attached to the appropriate image(s) in the PACS. The radiologist performs all the editing and corrections either by voice command or by manual typing (Marquez and Stewart, 2005). While voice recognition technology has made considerable advances in recent years, it still has some disadvantages. A particular concern is the potential for decreased face-to-face consultations between radiologists and physicians, given physicians have more immediate access to images and reports (Hayt et al, 2001), and issues related to change management for both physicians and radiologists from multiple organizational perspectives, including: 1) user involvement, 2) training and support, 3) a case for change, and 4) creating future opportunities (Bramson and Bramson, 2004). There is also evidence that the technology has not advanced to the point where it will replace traditional transcribing methods. A recent study of radiology residents in four large university-based residency programs in the United States reported the majority of residents surveyed felt the voice recognition system takes longer, and is not as reliable as the traditional method

(Gutierrez et al, 2005). An earlier study of teleradiology services also reported inefficiencies in voice recognition systems (Krupenski et al, 2003).

Technical Issues

Technical problems are always a possibility when new technology is introduced, and PACS is no exception. Problems with reliability of the system (Strickland 2000) and delayed access to images (Reed et al, 1996; Bryan et al, 1999; Inamura et al, 2001) were identified in early studies of PACS. The issue of storage also garnered quite a bit of interest in the late 1980s and early 1990s, mainly because the digital image was so large and the storage capabilities were limited. Recent advances in technology have resolved the issue of storage (Naul 2001), but other challenges still remain. These include access to historic images (Gamsu and Perex 2003; Gaytos et al, 2003), access to monitors and logging on to the system (Pilling, 2003), user friendliness (Cox and Dawe, 2002; Watkins 1999; Krupinski et al, 2003) and overall IT support (Hasley 2002; Hayt 2001; Bedel and Zdanowicz, 2004).

2.5 Benefits Evaluation Framework for PACS

2.5.1 Canada Health Infoway's Evaluation Framework for PACS

With $310 million to be invested in PACS in Canada by the end of 2007/08, Infoway recognized early in their mandate the need for a standard approach for measuring the benefits of PACS across various projects spanning multiple jurisdictions. Demonstrating benefits specific to improvements in health care access, quality and productivity would not only validate Infoway's investment, but also provide opportunities for documenting lessons learned as future PACS projects were implemented across the country.

In 2004, Infoway began working with several jurisdictions to develop a national approach that would facilitate consistency and credibility of PACS benefit evaluations (BE) across different settings in Canada. Infoway BE activities within Diagnostic Imaging (i.e., PACS) projects were initially developed through structured interviews conducted by experienced evaluators; key informants were identified by Infoway. There were six key informants interviewed from Fraser Health Authority (British Columbia), and 19 from Thames Valley Hospital Planning Partnership (Ontario). Those interviewed included physicians, as well as staff from administration, health records, radiology, IT, and emergency services. The purpose of conducting the interviews was to document feedback that would ultimately support the development of a national benefits framework for PACS projects. The key informants were asked specifically about their roles in the PACS implementation, the various technical and administrative activities necessary for implementation, and what they felt are the benefits of PACS.

As a result of this process, a list of potential indicator measures were identified and prioritized in terms of relevance, feasibility and importance. Infoway indicated to the researcher that this initial list of indicators numbered approximately 200. These 200 indicators were then presented to the *Diagnostic Imaging Expert Panel* brought together by Canada Health Infoway for the purpose of developing a national approach to measuring the benefits of PACS. The Panel, which consisted of one academic researcher with expertise in evaluation, three radiologists and four senior staff of Canada Health Infoway, reviewed the list of proposed indicators for the purpose of validation and relevancy. The outcome of this exercise produced 12 core indicator measures, categorized under six benefit areas: 1) increased user adoption, 2) decreased utilization (i.e., redundant tests increase costs and radiation exposure to patient), 3) improved productivity, 4) improved turn-around-times, 5) reduced patient transfers, and 6) cost per exam in film versus PACS.

1. *Increased User Adoption*

- Degree of Filmlessness
- % Digitally Stored Exams
- Number of Unique Clinician User Accounts
- Number of Active Users
- Number of Remote Users

2. *Decreased Utilization (duplicate tests)*

- Unnecessary Duplicate Exams

3. *Improved Productivity (radiologist and technologists)*

- Exams Dictated Per Radiologist Scheduled Hours
- Worked Productivity %

4. *Improved Turn-Around-Time (TAT)*

- Exam End to Dictation End TAT
- Total Turnaround Time

5. *Reduced Patient Transfers*

- Number of Patient Transfers

6. *Financial*

- Cost Per Case in Film versus in PACS

Infoway required that, where possible and practical, quantitative data for these 12 indicators would be collected from administrative systems each month for three months prior to PACS "going live", and each month for 9 months following the PACS "go live" date.

Infoway recognized from the very beginning that not all projects would be able to collect data for all twelve of these indicators. To supplement administrative data, a *PACS Opinion Survey* was developed by Infoway to collect subjective data from radiologists, radiology technologists and referring physicians on the benefits of PACS. The first versions of the *PACS Opinion Surveys* were developed by senior staff at Infoway and were based on previous PACS benefit evaluations identified through a literature review. These draft surveys were then submitted to the *Diagnostic Imaging Expert Panel* where further modifications were introduced to reflect the Canadian environment. The questionnaires were then piloted in 2004 at one hospital that was part of the Thames Valley PACS Project in Ontario. Following the pilot, the questionnaires were further modified by Infoway, and the decision was made at this time by the *Expert Panel* to exclude radiology technologists from future surveys. Infoway's rationale for excluding technologists from the evaluation framework was that the primary objective of the PACS evaluation was to focus on the physician environment, and address benefit areas such as improvements in efficiency, report turn-around-times, patient care, communications and satisfaction. For jurisdictions funded for PACS, Infoway required the survey be administered only once; 6 months following PACS "going live".

2.5.2 Newfoundland and Labrador's Evaluation Framework for PACS

A research project carried out by Neville, Gates, MacDonald et al (2004) entitled "Towards an Evaluation Framework for Electronic Health Records Initiatives", complemented the work of Infoway by proposing a framework which could be used to evaluate the benefits of EHR initiatives. Neville et al concluded that in the past, evaluations of health information systems generally were focused on: (1) technical features that impacted systems usage, (2) cost-benefit analysis, (3) user acceptance, and/or (4) patient outcomes. More recently, evaluation approaches have addressed the context and processes that contribute to outcomes, and have incorporated aspects of change management and innovation into the evaluation framework.

Neville's proposed benefits framework for carrying out evaluations of EHR initiatives was developed using a 4 step process: (1) a review of recent EHR related initiatives across Canada, (2) the team's personal involvement with EHR initiatives undertaken by NLCHI, (3) a systematic review of the literature, and (4) feedback from key informants on earlier drafts of the framework. The framework is relevant to a variety of stakeholders, including funders, policy makers, decision makers, users of the system, and researchers. It provides a practical guide to assist in identifying the types of questions which can be asked, options for answering these questions, and the tradeoffs that need to be considered depending on the type of evaluation approach taken.

Neville's main tenet is that the research team needs to work closely with all key stakeholders impacted by the implementation of the new information system/technology. This includes the sponsor (e.g., Infoway), provincial government departments (e.g., Ministry of Health, Treasury Board), vendors/project implementation teams, administration (e.g., Information Technology Directors) and health professionals (e.g., radiologists and referring physicians). The scope of deliverables for the benefits evaluation needs to be defined in collaboration with all parties through a priority setting exercise. Without an agreed upon framework, the overall evaluation is at risk of failure, given expectations among the parties will not be in agreement. For example, in evaluating PACS the benefits evaluation can focus on one or more very different benefit areas, such as improved patient health or developing a return on investment model.

Building on the work of Heathfield and Pitty (1998), Neville supports the position that there are three rationales for conducting a benefits evaluation: 1) The *Accountability Perspective,* where the goal is to answer questions regarding whether a particular intervention caused a particular outcome, 2) the *Developmental (or Performance) Perspective*, where the goal is to determine if an institution's overall performance has improved, and 3) the *Knowledge Perspective*, where the goal is to acquire a better understanding of some specific field. Using these three perspectives as a starting point, the evaluation team can then facilitate the development of a benefits evaluation framework in partnership with all key stakeholders.

As noted, a variety of methods can be used to collect data and information when undertaking an EHR benefits evaluation. Qualitative methods usually employ tools such as key informant interviews and focus groups, whereas quantitative methods rely on numerical data (e.g., administrative data or surveys). Qualitative and formative designs have frequently been used to address issues around the acceptance of the new technology and the influence of the host organization/system on the adoption process.

The evaluation framework developed by Neville et al was informed by the previous work of Heather Heathfield and the PROBE Project in the United Kingdom. The framework is presented below as a series of 7 steps, and can be used to evaluate a comprehensive EHR, or one or more specific domains of the EHR (e.g., PACS).

Step 1: Identification of Key Stakeholders in Each Jurisdiction

It is important that a wide range of stakeholders be involved in and appraised of the evaluation efforts within their own jurisdictions. At a national level, it is also important that key stakeholders are made aware of the evaluation, given it will facilitate: (1) evaluations becoming a strategic initiative requiring dedicated resources, (2) greater alignment of goals between the broader health system and those of EHR initiatives, (3) information exchange, (4) consensus on comparable evaluation approaches, and (5) the identification of champions at both the national and local levels.

Step 2: Orient Key Stakeholders to the EHR Initiative and Reach Agreement on Why an Evaluation is Needed

Communication with key stakeholders early in the process provides an opportunity to inform them of the evaluation being proposed. This will allow for the documentation of their: (a) expectations of the EHR initiative, and (b) views on what the evaluation plan should address. A workshop is a useful forum for this type of engagement, at which time an overview of the proposed evaluation approach can be presented and expectations and views documented. Given the wide-range of stakeholders (e.g., physicians, administrators and funders) involved with EHR initiatives, there will be different rationales for why an evaluation is needed. Each of these rationales may require measures collected by a variety of approaches, both qualitative and quantitative, however all will need: (1) assumptions about what the evaluation can contribute, (2) consensus on evaluation methods to be used, and (3) requirements in terms of the timelines and resources.

Step 3: Agree on When to Evaluate

Evaluation of EHR initiatives should occur over time and utilize multiple data collection points. When possible, the evaluation should involve data collection at 3 or more points: (1) pre-system implementation, (2) during implementation, and (3) post implementation (e.g., 6 and/or 12 months post implementation).

Step 4: Agree on What to Evaluate

There are any number of questions which could be posed about the benefits of EHR initiatives, although scarce resources (e.g., funding and qualified personnel) will limit the scope of any evaluation. To focus the evaluation, a priority setting exercise with key stakeholders can: (a) identify the questions that are important to answer, and (b) insure that all key stakeholders are part of the evaluation. One approach for such a priority setting exercise would be to build on the stakeholder identification process used to determine why an evaluation is important (Step 2).

Step 5: Agree on How to Evaluate

The methods which can be used to conduct the evaluation will depend on why the evaluation is undertaken and what is being evaluated. The evaluation team will need to consider the resources available and determine the best use of those resources with respect to scope and study design.

Step 6: Analyze and Report

Bringing together into a concise document the results of a multi-method evaluation of health information systems presents considerable challenges (Heathfield et al, 1999; Herbst et al, 1999; Moehr 2002; Lau 1999). Each key stakeholder will have their own focus, and the original evaluation plan may have migrated into several evaluation sub-projects, each employing different methods and involving different disciplines. To mitigate against this divergence, findings from each evaluation sub-project contained within the evaluation initiative should be shared with key stakeholders noted in Step 1. A workshop setting would allow for face-to-face dialogue on how best to present the results obtained through different sub-projects.

Step 7: Agree on Recommendations and Forward Them to Key Stakeholders

Stakeholders who attend the workshop (Step 6) are those who should also be involved in developing the recommendations to be included in the final report. Developing recommendations may prove to be relatively straightforward, or they could result in considerable debate. Recommendations from developmental-oriented studies may face some degree of give and take within the evaluation team, whereas

> accountability-oriented studies can anticipate considerably more deliberation. There is no guarantee that by involving all key stakeholders early in the process there will be a smooth transition to recommendations at the end of the process. However, in using this approach, consensus on at least some of the key issues will be arrived at, especially if those involved are: (a) familiar with the main issues from the start, (b) aware of the different perspectives each team member brings to the discussion, and (c) comfortable that the variety of methods used in the evaluation produced the most unbiased results possible.

Many of the studies reviewed in Chapter 2 provided initial guidance into the development of the approach used to address the objectives of this current study. It was determined that to maximize the probability of successfully completing a comprehensive evaluation of PACS in Newfoundland, a comparative approach using triangulation of data and extensive stakeholder engagement would be required. These previous studies also informed the researcher of several challenges faced in carrying out a PACS evaluation, and allowed for the incorporation of these lessons learned into the current study. Prior knowledge that objective benefit indicators of PACS are not easily measured, and that the diversity of PACS environments will impact on the results of the evaluation, proved beneficial in designing this current study.

Chapter 3
Methods

In Chapter 3, the approach and design of the evaluation are described, along with a brief overview of the study setting. The methods used in collecting and analyzing data from surveys, key informant interviews, administrative databases, and project documentation are provided.

3.1 Evaluation Approach

Towards an Evaluation Framework for Electronic Health Records Initiatives (Neville, Gates, MacDonald et al, 2004) guided the evaluation through a series of steps, with emphasis on stakeholder involvement at each step and triangulating data wherever possible.

3.2 Study Design

The evaluation was designed as a pre/post comparative benefits study. As part of the study design process, the proposed approach was presented at a pre-evaluation workshop attended by key stakeholders. The purpose of the workshop was to present and obtain feedback on the key objectives of the study, the core research questions to be investigated, and the data collection tools to be used. From a pragmatic perspective Canada Health Infoway's *Electronic Diagnostic Imaging Indicators Reference Document* (August 22, 2005) provided the set of twelve (12) quantitative indicators (see Section 2.5.1) considered important by Infoway for measuring the benefits of PACS. As such, these 12 indicators were incorporated into the study design.

For the majority of the 12 Infoway indicators, data would be collected from administrative databases each month for 3 months pre PACS implementation, and each month for 9 months post implementation, for a total of 12 data points. Questionnaires were administered pre and post PACS implementation to radiologists, radiology technologists and referring physicians to measure perceived benefits and challenges with PACS. Financial documents and spreadsheets were reviewed to estimate the total cost of PACS ownership and the cost per exam in film versus PACS. Key informant interviews were carried out post PACS implementation.

3.3 Study Setting

The setting for the study was the island portion of the province of Newfoundland and Labrador; the Labrador-Grenfell Health Authority was excluded from the study design given delays in implementing PACS in that region. The timeline built into the study proposal was 33 months and was to run from June 2005 –

March 2008. This 33 month window included a 9 month post PACS data collection period. As of January 2008, all sites in Labrador-Grenfell Health Authority had still not "gone live" with PACS.

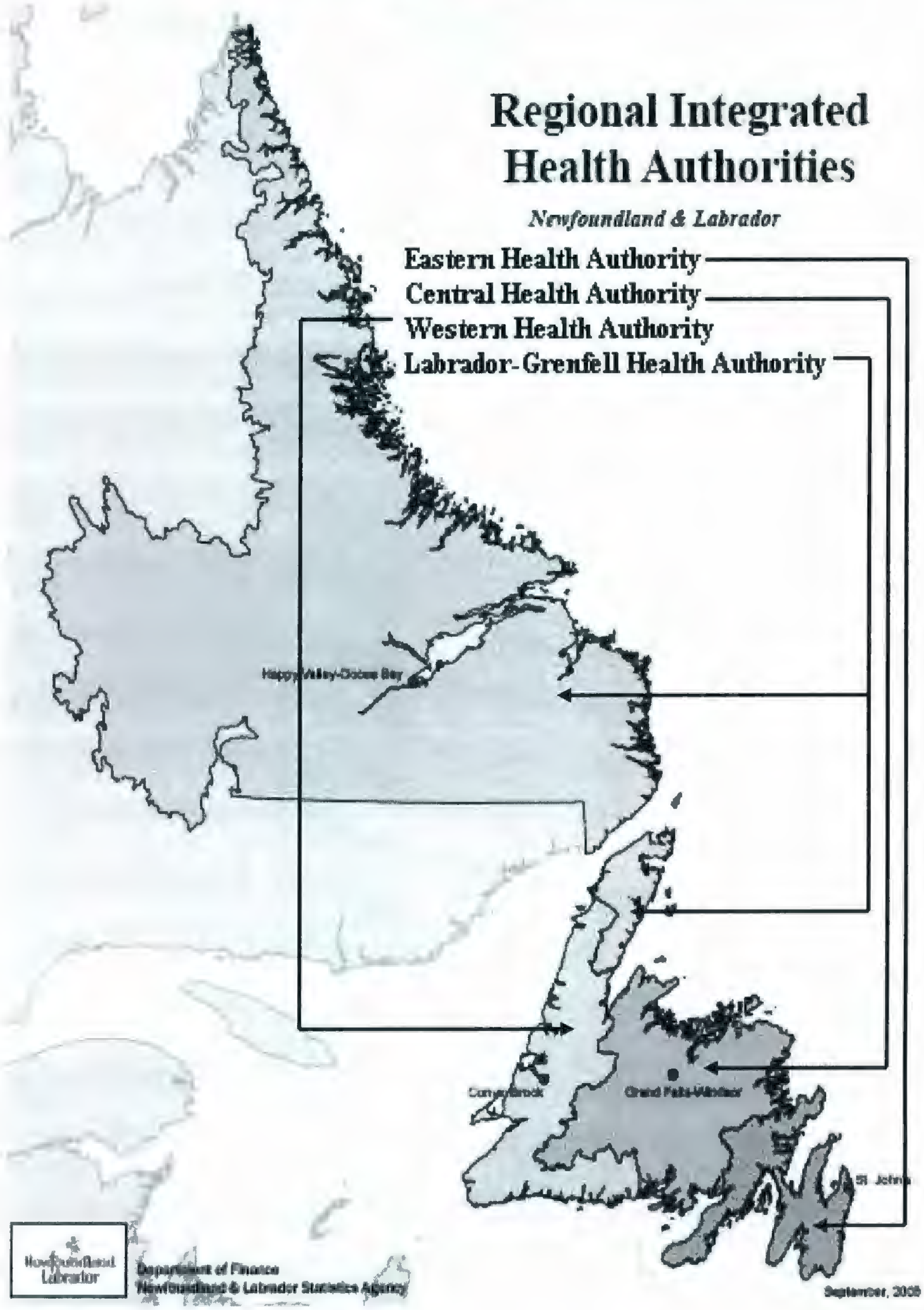
In April, 2004 a restructuring of the health system in Newfoundland and Labrador resulted in eight health boards (See Figure 1, p. 15) being reduced to four integrated health authorities (See Figure 2, p. 72): Eastern Health Authority, Central Health Authority, Western Health Authority and the Labrador/Grenfell Health Authority. The majority of the province's population resides in the Eastern Health Authority (Table 3-1).

Table 3-1
Population (2006) by Health Authority
Newfoundland and Labrador

Health Authority	Population
Eastern	293,682 (58.1%)
Central	95,607 (18.9%)
Western	79,034 (15.6%)
Labrador-Grenfell	37,146 (7.3%)
Province	505,469

Source: NL Centre for Health Information
Statistics Canada

Figure 2
Newfoundland and Labrador Health Authorities (2004-present)



In 2006/07, there were 31 sites in the province of Newfoundland and Labrador classified as acute care, with the number of beds per site ranging from 1 to 332 (Appendix "A"). There are several smaller health centres in the province, however they have no acute care beds and their administrative reporting falls under larger sites within their respective health authorities.

Only sites in the Terrier and Mastiff Health Authorities (Note: Pseudo names used for authorities and sites; see Ethics p. 87) were able to provide administrative data for some of the twelve (12) indicators proposed by Infoway. In the Terrier Health Authority, the implementation of PACS was carried out during calendar years 2005 and 2006; such timelines permitted a pre/post evaluation approach. In the Mastiff Health Authority, PACS was implemented in most sites by 2004, while in the Spaniel Health Authority most sites had implemented PACS by 2001. Given the number of years that had past since PACS was implemented, hospital administration informed the researcher that there would be limited pre PACS administrative data available in the Mastiff Authority, and none in the Spaniel Authority.

Radiologists, physicians and technologists were administered a pre PACS survey in the Terrier Health Authority. The post PACS survey was administered to physicians and radiologists in the Mastiff, Spaniel and Terrier Health Authorities, and to technologists in the Terrier Health Authority. While Infoway made the decision to exclude technologists from their evaluation framework, for the Newfoundland and Labrador study, technologists were included in the pre and post PACS survey of the Terrier Health Authority. This study presented a unique opportunity to survey this professional cohort in an area that never had PACS prior to the 2005 implementation.

A summary of PACS sites included in the evaluation in the three health authorities on the island portion of the province, their go-live dates, and the evaluation tools employed is summarized in Table 3-2.

Table 3-2
PACS Go-Live Date by Site and Evaluation Tools Used

Site by Regional Health Authority	PACS Go-Live Date*	Admin. Data Pre/Post PACS	Survey Pre PACS	Survey Post PACS	Total Cost of Owner-Ship	Cost per Exam Analysis	Key Inform. Inter-views
Mastiff							
Hospital_ K	Not Live	NO					
Hospital_L	Jun 2004	NO					
Hospital_M	Jan 2003	NO					
Hospital_N	Not Live	NO					
Hospital_O	Not Live	NO					
Hospital_H	Sept 2004	YES					
Hospital_P	Jan 2002	NO	NO	YES	NO	NO	YES
Hospital_I	Oct 2004	YES					
Hospital_J	Nov 2004	YES					
Hospital_Q	Jun 2002	NO					
Hospital_R	Jun 2002	NO					
Hospital_S	Jun 2002	NO					
Spaniel							
Hospital_T	1998	NO					
Hospital_U	1998	NO					
Hospital_V	1998	NO					
Hospital_W	1998	NO					
Hospital_X	2001	NO	NO	YES	NO	NO	YES
Hospital_Y	2001	NO					
Hospital_Z	2001	NO					
Hospital_AA	2001	NO					
Hospital_BB	2001	NO					
Terrier							
Hospital_C	Jun 2006	YES					
Hospital_F	May 2006	YES					
Hospital_A	Dec 2005	YES					
Hospital_B	Mar 2006	YES	YES	YES	YES	YES	YES
Hospital_D	Apr 2006	YES					
Hospital_E	May 2006	YES					
Hospital_G	Dec 2005	YES					

* "Live" indicates PACS operational. As of March 2007 Source: Regional Diagnostic Imaging Directors

3.4 Study Instruments

3.4.1 Survey Questionnaires

Two separate survey instruments were developed for this study, a questionnaire administered to both radiologists and radiology technologists (Appendix B), and a second questionnaire for referring physicians (Appendix C). The questionnaires were based on the two *PACS Opinion Surveys* previously developed by Infoway: 1) Referring Physician Opinion Survey, and 2) Radiologist/Technologist PACS Opinion Survey. As described in Section 2.5.1, the Infoway questionnaires were developed through a literature review by senior staff at Infoway, vetted through the Diagnostic Imaging Expert Panel, and piloted in one PACS hospital. These questionnaires were subsequently modified for the Newfoundland environment following consultation with the researcher's supervisory committee, feedback from the stakeholder workshop, and completion of an extensive literature review (Appendix "D"). Drafts of the questionnaires were submitted for review to those stakeholders who had participated in the pre-evaluation workshop, as well as two radiologists who were members of the Provincial PACS Steering Committee. The primary objective of this review was to obtain feedback from stakeholders on the relevance of the survey questions in relation to the overall objectives of the study. Following this review, minor revisions were made to the questionnaires.

Questionnaires for both the radiologists/technologists and the referring physicians were separated into four sections. The first section captured information on the respondents' PACS environment, the second section looked at perceived benefits of PACS, the third section dealt with perceived challenges, while the fourth section was specific to respondent demographics. A four-point Likert scale and a categorical approach were used to solicit responses for the majority of questions. An opportunity to include general comments was provided by an open-ended question at the end of the questionnaire.

3.4.2 Key Informant Interview Script

Draft key informant interview scripts for PACS end users and management personnel were developed based on feedback from the pre-evaluation workshop, advice from the researcher's supervisory committee, and a preliminary analysis of the survey. The purpose of the key informant interviews was to gather in-depth feedback on lessons learned and facilitators of, and barriers to, the successful implementation of PACS.

The final scripts (Appendix "E") were submitted to, and approved by, the researcher's supervisory committee.

3.4.3 Administrative Data

3.4.3.1 Benefit Measures: Canada Health Infoway

As noted previously, Canada Health Infoway developed twelve (12) benefit indicators, data for which would be collected from administrative databases pre and post PACS implementation. The definitions of the indicators along with a summary of the data collection methods are provided under six (6) main benefit areas: 1) increased user adoption, 2) decreased utilization, 3) improved productivity, 4) improved turn-around-times, 5) reduced patient transfers, and 6) cost per exam in film versus PACS

1) *Increased User Adoption*

- Degree of Filmlessness

  Definition: Archiving in digital form on PACS for all diagnostic images within scope. This is a binary variable.

Method: Completed 30 consecutive (calendar) days of 95% filmless operation. To be collected from the Radiology Information System.

- % Digitally Stored Exams

  Definition: The proportion of digitally stored exams versus hard copy film.

  Method: Total number of exams stored digitally divided by the total number of exams (digital and film). To be collected from the Radiology Information System each month for 3 months pre PACS and from the Radiology Information System and PACS each month for 9 months post PACS implementation.

- Proportion of Unique Clinician User Accounts

  Definition: Number of unique clinicians who have been provided access to the PACS system.

  Method: Total number of unique clinician users accounts divided by the total number of clinicians on staff. To be collected from PACS each month for 9 months post PACS.

- Proportion of Active Users

  Definition: A measure of use of the system by examining the change in the number of unique individuals who actually use the PACS system.

  Method: Total number of unique users logged-on divided by total the number of unique user accounts. To be collected from PACS each month for 9 months post PACS.

- Proportion of Remote Users

  Definition: A measure of remote users (e.g. access from outside the hospital).

  Method: Total number of remote users logged-on divided by the total number of unique user accounts. To be collected from PACS each month for 9 months post PACS.

2) *Decreased Utilization (duplicate tests)*

- Unnecessary Duplicate Exams

  Definition: A measure of the impact of PACS on the number of duplicate tests due to lack of exam availability when required.

  Method: Number of repeat exams due to lack of availability divided by the number of total exams. To be collected from the

Radiology Information System each month for 3 months pre PACS and from PACS for 9 months post PACS.

3) *Improved Productivity (Radiologist)*

- Exams Dictated Per Radiologist Scheduled Hours

  Definition: A measure the impact of PACS on the productivity of radiologists.

  Method: Number of exams dictated per FTE radiologist scheduled clinical hours. To be collected from the log of scheduled hours for Radiologists, Dictation System/Radiology Information System for exams dictated (read) for each month 3 months pre PACS and from Radiology Information System for 9 months post PACS.

- Worked Productivity %

  Definition: A measure of productivity of unit-producing personnel (UPP) within the radiology department.

  Method:

  Option A:

  (Service Recipient Workload Units / 60) * 100 UPP divided by Unit-Producing Personnel Worked and Purchased Hours. According to MIS 2004, Unit-Producing Personnel Worked

Productivity (%) is the percentage of all unit-producing personnel worked hours and purchased hours spent in the delivery of services to or on behalf of specific service recipients.

Option B:

Exam volume/Full-Time Equivalent (FTE) by Profession * 100

Option C:

Total resource cost /exam volume *100

To be collected from the Radiology Information System and the Management Information System for each month 3 months pre PACS and for 9 months post PACS.

4) *Improved Turn-Around-Time (TAT)*

- Exam End to Dictation End TAT

  Definition: A measure of the impact on the process time from exam completion to when the report has been dictated by the radiologist.

  Method: Sum of (report dictation completion time – exam completion time) divided by total exams. To be collected from the Radiology Information System and Modality Logs for each month 3 months pre PACS and from the Radiology Information

System, Modality Logs and PACS for each month for 9 months post PACS.

- Total TAT

  Definition: A measure of the impact on the process time from patient check-in in Diagnostic Imaging to when verified report is available to referring physician.

  Method: Sum of (time verified report available– time of check-in) divided by total exams. To be collected from the Radiology Information System for each month 3 months pre PACS and for each month 9 months post PACS.

5) *Reduced Patient Transfers*

- Patient Transfers

  Definition: A measure of the impact of PACS on the number of patient transfers between facilities due to the ability to share images and consult remotely.

  Method:

  Option A:

  Counts of reason for transfer divided by counts of transfers to other sites.

Option B:

Transfers related to not having on site consultation post PACS divided by transfers related to not having on site consultation pre PACS.

For Option A and B data is to be collected from audit sheets and discharge abstract data for each month 3 months pre PACS and for each month for 9 months post PACS.

6) *Cost per Exam in Film versus PACS*

- Cost per Exam in Film versus in PACS

  Definition: Average cost per exam in a film-based environment compared to the average cost per exam in a PACS environment.

  Method (1):

  Annual expense details for 12 months pre and 12 months post PACS implementation. An estimated cost per exam in film and in PACS would be derived from financial records provided by the Terrier Health Authority, Canada Health Infoway re-imbursement schedules, and financial spreadsheets and budget documents provided by NLCHI. Cost estimates in the film and

PACS environments would be estimated based on the following items:

Exam Utilization

- Total exam volume
- Estimated exam volume increase

Film Environment

- Film
- Master and Insert Bags
- Paper Related Expenses
- Chemical Purchase
- Chemical Disposal
- Maintenance
- Courier
- Storage
- Staff
  - Librarians/Clerks
  - Dark Room Staff

PACS Environment

- Site Specific PACS Services
- Local Image Volume Maintenance
- Network Service Contract
- PACS Service Contract
- Data Centre Support Maintenance
- Staff
  - PACS Administrator
  - PACS support staff

Method (2):

A second method used to calculate the cost per exam in the PACS environment utilized a constant payment schedule (one a year for 10 years) and a constant interest rate (6%).

3.4.4 Total Cost of Ownership

Total cost of ownership (TCO) is a high-level summary of costs incurred in the planning, building, implementing, operating, and maintaining of information systems. PACS project costs were identified following a review of project documents provided by NLCHI, including: PACS Project Charter, Canada Health Infoway re-imbursement schedules, and summary financial spreadsheets and budget documents.

3.5 Ethics

Ethics approvals were obtained separately for each of the following phases of the evaluation: 1) pre-evaluation workshop, 2) administrative indicator data and pre PACS survey, 3) post PACS survey, and 4) key informant interviews. The study protocol along with the survey cover letters, questionnaires, data collection tools, and key informant interview guides were submitted to Memorial University's Human Investigation Committee (HIC) for approval. Approval letters from HIC for each of the four phases are provided in Appendix "F". In addition to ethic's approval being obtained from HIC, the NLCHI Privacy Officer requested that the actual names of the health authorities and hospitals from which data was collected during this study be replaced with pseudo names. This is because hospital names in Newfoundland and Labrador are considered identifiable data. As such, the three Health Authorities under study were re-named "Terrier", "Mastiff" and "Spaniel", while all hospitals within these authorities were re-named using a basic sequence of the alphabet.

In order to safeguard the privacy of respondents, all data collected for this study were entered into SPSS (Version 15.0, SPSS Inc) and stored on the researcher's computer, which was password protected. The computer was located in an office with a door that could be locked when vacated. Other than the researcher, no other person was authorized to access this database. The completed questionnaires, data collection sheets and materials from the key informant interviews were stored in a locked filing cabinet in the investigator's office. No personal identifiers were attached to the any data collection tool used in the study.

3.6 Data Collection

3.6.1 Pre-Evaluation Workshop

Upon receiving ethics approval on June 29, 2005, a pre-evaluation workshop was held on September 8th, 2005. As the evaluation framework required significant stakeholder involvement, key individuals in each of the three health authorities on the island were invited to the workshop where they were given: 1) an orientation to the evaluation framework, 2) a presentation on PACS evaluations previously completed in British Columbia and Ontario, and 3) an overview of the benefit areas already identified by Canada Health Infoway as core to the PACS evaluation (i.e., the 12 benefit indicators). Workshop participants included representatives from GE Healthcare (i.e., PACS Vendor), Canada Health Infoway, representatives from each of the three heath authorities in which PACS would be evaluated, including IT Directors, PACS Administrators, Directors and Managers of Radiology, the provincial PACS Project Manager, representatives from the HIN Project Team of NLCHI, and Dr. Doreen Neville, PhD supervisor to the researcher.

Following the orientation and presentations, attendees were divided into three groups with instructions to: 1) validate the twelve PACS benefit indicators put forward by Canada Health Infoway, 2) validate the draft objectives and proposed research questions identified by the researcher, and 3) provide feedback on the draft questionnaires. In reviewing the proposed research questions, participants were asked to reflect on their current work environment, and to propose any additional questions which they feel would be important in measuring the benefits of PACS.

Following the morning workshop, a summary session was held with all participants where each group presented their feedback on the proposed evaluation design/questionnaire and presented additional research questions that were identified based on the discussions generated.

3.6.2 Pre and Post PACS Administrative Data

Ethics approval for collection of administrative data was granted on November 3, 2005. A data collection definition document and data collection tool (Excel spreadsheet) based on Infoway's twelve (12) indicators was provided to the PACS Administrators in the Terrier and Mastiff Health Authorities. The Spaniel Health Authority was excluded from the collection of administrative data as this Authority had completed implementation of PACS seven (7) years previously and had reported to the researcher that no administrative data would be available from that time period.

Administrative data was collected primarily from the hospitals information system (Meditech), the Radiology Information System (RIS) and PACS. Prior to the start of data collection, the researcher met with the PACS Administrators in the Mastiff and Spaniel Authorities to explain the study and to review the data collection procedure for each of the 12 indicators.

Throughout the 12 month data collection period (3 pre PACS and 9 post PACS) the researcher continued to communicate with the PACS Administrators via e-mail and phone to solve any problems and to answer any questions they had regarding data collection.

3.6.3 Pre PACS Surveys

Ethics approval for administering the Pre PACS survey was granted on November 3, 2005. At that time, the Mastiff and Spaniel Health Authorities had completed implementation of PACS at most of their sites, therefore only the Terrier Health Authority was administered the pre PACS survey. The Newfoundland and Labrador Medical Association (NLMA) provided the researcher with the business addresses for all radiologists and referring physicians in the province. The Director of Radiology in the Terrier Health Authority was provided survey packages by the researcher to be distributed to all radiology technologists in relevant sites within that Authority. To encourage physicians, radiologists and radiology technologists to respond, the questionnaire was anonymous and a pre-stamped return envelope was provided with each survey package. There were no personal identifiers captured on the questionnaire. The pre PACS survey packages were administered to all radiologists (n=6), all radiology technologists (n=45), and all referring physicians (n = 120) in the Terrier Health Authority on September 9, 2005, three months prior to PACS going live (Table 3-3).

Table 3-3
Pre PACS Surveys: Terrier Health Authority

Region	Pre PACS Surveys Mail Out		
	Radiologists	Physicians	Technologists
Mastiff	n/a	n/a	n/a
Spaniel	n/a	n/a	n/a
Terrier	6	120	45
Total	6	120	45

A second survey was administered three weeks later on September 30, 2005. The cover letter included with the second mail-out indicated this was a second request for completing the questionnaire, and thanked those that had responded to the first mail-out, and not to respond a second time.

3.6.4 Post PACS Surveys

Ethics approval for administering the post PACS survey was granted on November 30, 2006. The post PACS survey mirrored the pre PACS survey in both content and process, the only difference being the questions were re-worded to ask for opinions of PACS following at least 12 months of use (i.e., post PACS), rather then expectations prior to having PACS available (i.e., pre PACS). As a year had past since the pre PACS survey was administered, the Newfoundland and Labrador Medical Association

(NLMA) provided the researcher with the updated business addresses for all radiologists and referring physicians. The Director of Radiology in the Terrier Health Authority again distributed the surveys for the radiology technologists to the appropriate sites within that Authority.

Recipients of the post PACS survey were all radiologists (n=6), radiology technologists (n=45) and referring physicians (n=125) in the Terrier Health Authority, all radiologists (n=37) and referring physicians (n=659) in the Mastiff Health Authority, and all radiologists (n=7) and referring physicians (n=148) in the Spaniel Health Authority. The total post PACS questionnaires administered in the three health authorities included 932 referring physicians, 50 radiologists and 45 radiology technologists. The first survey was administered on January 17th, 2007 with a second survey was administered on February 7th, 2007.

Table 3-4 provides a summary of the number of post PACS surveys administered.

Table 3-4
Post PACS Surveys Mailed-out
Mastiff, Spaniel and Terrier Health Authorities

Region	Post PACS Surveys Mail Out		
	Radiologists	Physicians	Technologists
Mastiff	37	659	n/a
Spaniel	7	148	n/a
Terrier	6	125	45
Total	50	932	45

3.6.5 Key Informant Interviews

Key Informants

Ethics approval for carrying out the key informant interviews was granted on February 15, 2007. A semi-structured interview script (Appendix E) was used to solicit feedback from key informants in the three health authorities on the island portion of the province. Interviews were conducted to obtain perceptions of PACS with respect to: 1) benefits, 2) unintended consequences, 3) the implementation process, 4) training, and 5) lessons learned. Key informants were separated into two categories: 1) PACS end-users, which included radiologists, physicians, radiology technologists and PACS Administrators, and 2) PACS Management, which included Information Technology Directors, Directors of Diagnostic Imaging, Managers of Diagnostic Imaging, the Health Information Network (HIN) Director at NLCHI, and the Provincial PACS Project Manager.

Consent Process

E-mail addresses and telephone numbers for radiologists, radiology technologists and administrative staff were provided to the researcher by the Diagnostic Imaging or Information Technology Departments in PACS sites, or NLCHI. For each potential interviewee, the researcher emailed an interview request (Appendix "G") along with the Elements of Consent document (Appendix "H"). One week following the initial contact by e-mail, the researcher telephoned each candidate and using the pre-defined script (Appendix "G"), asked if the key informant would consent to be interviewed.

There is no provincial source from which e-mail addresses for physicians could be obtained. To contact this group, business phone numbers available on the College of Physicians and Surgeons of Newfoundland and Labrador website (http://www.nmb.ca/FindDoctor.asp) were obtained. Given that no advance e-mail was possible, the follow-up phone call script

(Appendix "I") was modified slightly and the second paragraph removed, and then used when a physician was contacted by phone. Once contacted, the physician was informed of the study and asked if they would be interested in receiving the "Elements of Consent" document in advance to consenting to an interview. If the physician asked to receive the "Elements of Consent" document, this was sent by e-mail to the address provided by the physician. Allowing a week for the physician to review the "Elements of Consent", the physician was contacted again either by e-mail or telephone, to arrange a convenient time to do the interview. Table 3-5 lists the documents and guides used in carrying out the key informant interviews.

Table 3-5
Key Informant Documents and Guides

Guide/Document	Location
DI/IT/PACS Administrator Interview Guide	Appendix E-1
Radiologist/Technologist/Physician Interview Guide	Appendix E-2
Initial Invitation Email for Telephone Interviews	Appendix G-1
Follow-up Phone Script for Telephone Interviews	Appendix G-2
Initiating Interview Telephone Script	Appendix G-3
Elements of Consent Document	Appendix H
Modified Phone Call Script to Physicians	Appendix I

Key Informants Contacted

All 46 radiologists practicing in the Terrier, Mastiff and Spaniel Health Authorities were contacted and asked to participate in the interview. Only radiology technologists practicing in the Terrier Health Authority were contacted for an interview (n = 45). All Diagnostic Imaging Directors/Managers, PACS Administrators and Information Technology Directors in each of the three Health Authorities were contacted. The HIN Director (NLCHI) and the Provincial PACS Project Manager, both of which had provincial responsibilities, were contacted.

In June 2007, a total number of 932 physicians were registered on the College of Physicians and Surgeons website; 541 were identified as general practitioners and 391 were specialists. A convenience sample of 100 physicians, 58 general practitioners and 42 specialists, were randomly selected (i.e., every 10^{th} physician on list systematically selected) from the website to be phoned and asked to consent to an interview. Table 3-6 provides a summary of key informants initially contacted.

Table 3-6
Key Informants Contacted for Interview

Type of Key Informant	# Contacted For Interview
End-Users	
Radiologist	48
Radiology Technologist	45
PACS Administrator	3
Physician (n=100)	
General Practitioner	58
Specialist	42
PACS Management	11
Total	206

3.7 Data Analysis

3.7.1 Survey Questionnaires

Data from the pre and post PACS questionnaires were entered into SPSS version 15.0. Analysis consisted of descriptive analysis (e.g., means and frequencies) and comparative statistics (Chi-Square and Fisher Exact tests). For Chi-Square/Fisher Exact tests, if the resulting p-value was < 0.05 we rejected the null hypothesis (H_o). An example of hypothesis testing employed in the analysis is as follows:

H_o: Physicians' level of agreement that they will experience difficulty finding an exam and the implementation of PACS are independent

Versus

H_a: Physicians' level of agreement that they will experience difficulty finding an exam and the implementation of PACS are not independent

<u>Open-Ended Question</u>

The single open-ended question was analyzed by the researcher using a method of content analysis that determines the number of times certain qualities appear in a written text (Duncan 1989). Content analysis is a method used to determine the content of written communications by using a systematic, objective, and quantitative procedure and is especially useful in quantifying responses to open-ended survey questions. It is an analysis of written communication that results in categorization and classification of the written text.

There are four common coding units in content analysis: a word, a set of words, a sentence, or a theme (Busch et al, 2005). In analyzing the open ended question asked in this study, two coding units were utilized; words and themes. Within the context of the study, words and themes were classified into one of two distinct groups (benefits or challenges), and then these groups further classified. For example, a benefit of PACS identified might be access to exams, whereas further classification would identify access to historical exams versus access to primary exams. (See section 3.7.3 on key-informant interviews for further discussion on content analysis).

3.7.2 Administrative Data

Administrative data provided by the regions were entered into SPSS version 15.0. Analysis consisted mainly of descriptive analysis (e.g., means and frequencies). In investigating report turn-around-times (TAT), the mean TAT (in hours) was calculated for a minimum of three-months pre-implementation and for up to 12 months post-implementation. The mean TAT was derived for each pre/post period, excluding the month that PACS was implemented.

A one-way analysis of variance (ANOVA) was used to determine if there was a statistically significant difference between the pre and post PACS periods on the mean report TAT. The report TAT was considered the dependent variable and pre-post PACS time period the independent variable. A p-value of <0.05 would signify a significant difference in TAT between pre and post PACS.

To show the slope of data points a regression line was superimposed over the bar graphs using Microsoft Excel (1997). This line is included only to represent a visual trend over time of TAT's pre and post PACS. For regression, the data set was represented as (x_i, y_i), where y_i represented the mean TAT in hours and x_i represented the month the exam was performed. To show if there is any relationship between the variables x and y, the regression line was generated from the basic regression equation $y = a + bx$, where "a" represents the y-intercept and "b" represents the slope.

3.7.3 Key Informant Interviews

Each of the key informants who participated in the interviews agreed to be recorded. The interviews were transcribed and organized in a binder by type of PACS end-user and PACS management. Given that the interviews employed a semi-structured script, the method chosen for analyzing the text was *Content Analysis*. As noted previously in section 3.7.1, content analysis is a method of analysis used to determine the frequency with which certain qualities appear in a document(s). The ultimate goal of content analysis is to reduce the full text under investigation into major themes, summary categories and sub-categories. This hierarchy of coding lends itself to analysis. Such coding is sometimes referred to as selective reduction, and depending on the level of analysis desired, these summaries can consist of a single word, a set of words, a sentence, or a theme.

In analyzing the transcribed PACS interviews, each area of PACS discussed in the interview (i.e., perceived benefits, unintended consequences, the implementation process, training, lessons learned and overall perceptions of PACS) was thoroughly studied prior to being grouped into common themes. Following systematic reviews of the transcripts, categories and sub-categories were identified from the themes. The analysis was completed once further re-coding would only result in the sub-categories becoming so micro that the analysis would lose its value (i.e., saturation). An example of a completed content analysis would have a major theme identified, such as "Benefits of PACS", with a category under "Benefits of PACS" being "Accessibility to Exams", and a sub-category under "Accessibility to Exams" being "Access to Historical Exams".

Chapter 4
Results

The study employed four (4) primary methods of data collection: survey questionnaires, hospital administrative data, project management documents (e.g., financial and project scopes), and key informant interviews. Following a summary of the key informant workshop (as feedback coming out of the workshop influenced the design of the study) results for each of the data collection methods are presented.

4.1 Key Informant Workshop

Based on feedback from key informants attending the workshop, a total of nine (9) research questions were identified as priorities for evaluating the benefits of PACS in Newfoundland and Labrador:

1) Was the anticipated utilization/adoption of PACS achieved?
2) Was there a reduction in unnecessary duplicate exams?
3) Did productivity improve for both radiologists and technologists?
4) Did turn-around-time for reports improve?
5) What was the impact on patient transfers between sites (i.e., as a result of the ability to share images electronically and consult remotely)?
6) What was the cost per exam in a film-based environment compared to the cost per exam in a PACS environment?
7) What were the total costs of implementing the PACS system and how do they compare to estimated costs pre-implementation?

8) What degree of access occurs in rural versus urban areas?

9) What were the lessons learned (e.g., was the end-user training adequate)?

Research questions 1-6 had previously been identified by Canada Health Infoway as core to evaluating the benefit of PACS. The additional three research questions (7-9) recommended by the key stakeholders were investigated further in the workshop to determine what measures could provide data to answer these additional questions. A summary of these deliberations is provided in Table 4-1. A more detailed summary is provided in Appendix "J".

Table 4-1
Additional Research Questions and Indicator Measures

Area of focus	Indicators

What were the total costs of implementing the PACS system and how do they compare to estimated costs pre-implementation?	• Project scoping/needs assessment
	• Technology (hardware, software, networking, etc)
	    • capital
	    • maintenance/on-going
	• Personnel
	    • Training/user support (both initial and on-going)

What degree of access occurs in rural versus urban areas?	• Number of exams read remotely for Rural residents (pre/post) • Number of reports sent to rural physicians (pre/post) • Survey questions for rural/urban physicians on value of PACS (pre/post)

Lessons Learned	• Characteristics of champions for technology
	• Key facilitators and barriers to success (e.g. team functioning at pre-implementation)
	• Change management requirements
	    • support during implementation
	    • contingency plans
	    • privacy protocols
	• Unexpected consequences

4.2 Surveys

4.2.1 Administration of Questionnaires

Questionnaires were administered to physicians, radiologists and radiology technologists to solicit feedback on both the benefits and the challenges with PACS. The approach used in administrating the survey differed within the three health authorities depending on when PACS was implemented, and the professional group being surveyed.

Mastiff: Post PACS Survey - Physicians and Radiologists

Administration of the post PACS surveys were directed at physicians and radiologists working within the Mastiff Health Authority. Surveys were administered in January, 2007. Depending on the site, the time from when PACS was implemented to when the survey was mailed out, ranged from 3-5 years. The implementation of PACS occurred in the majority of sites within the Mastiff Health Authority over the period 2002-2004.

Spaniel: Post PACS Survey - Physicians and Radiologists

Administration of the post PACS surveys were directed at physicians and radiologists working within the Spaniel Health Authority. Surveys were administered in January, 2007. Depending on the site, the time from when PACS was implemented to when the survey was mailed out, ranged from 6-9 years. The implementation of PACS occurred in the majority of sites within the Spaniel Health Authority over the period 1998-2001.

Terrier: Pre/Post PACS Survey – Physicians/Radiologists/Technologists

Pre and post PACS survey were administered to physicians, radiologists and radiology technologists in October, 2005 (three months pre PACS implementation) and in January 2007 (12 months post PACS implementation). PACS was implemented in the majority of sites within the Terrier Health Authority by January, 2006.

4.2.2 Questionnaire: Classification of Level of Agreement

In soliciting responses on the perceived benefits and challenges of PACS the questionnaires for physicians, radiologists and radiology technologists utilized a four-point Likert scale: 1) Strongly Disagree, 2) Moderately Disagree, 3)

Moderately Agree, and 4) Strongly Agree. Given the small sample sizes for some response groups, and for the purpose of using 2x2 chi-square tests, these four categories were collapsed such that "Disagree" included "Strongly Disagree" and "Moderately Disagree", and "Agree" included "Moderately Agree" and "Strongly Agree".

4.2.3 Classification of Percent Agreement

For the purpose of reporting levels of agreement specific to those questions measuring the perceived benefits and challenges of PACS, the following categories were used:

Strong Agreement	80% - 100%
Moderate Agreement	70% - 79%
Modest Agreement	50% - 69%
Minimal Agreement	20% - 49%
Little Agreement	0% - 19%

4.2.4 Comparative Analysis

The comparison in levels of agreement between physicians, radiologists and radiology technologists across the three health authorities was limited to those comparisons which yielded sufficient sample sizes and were relevant to the study objectives. A summary of the samples sizes by health authority and professional groups is provided in Table 4-2.

Table 4-2
Sample Size: Pre and Post PACS Survey
Mastiff, Spaniel and Terrier Health Authorities

Profession	Health Authority Pre PACS Implementation			Total
	Mastiff	Spaniel	Terrier	
Physicians	n/a	n/a	n=38	n=38
Radiologists	n/a	n/a	n= 2	n= 2
Technologists	n/a	n/a	n=18	n=18
Profession	**Health Authority Post PACS Implementation**			
	Mastiff	**Spaniel**	**Terrier**	**Total**
Physicians	n=241	n=51	n=43	n=335
Radiologists	n= 20	n= 2	n= 5	n= 27
Technologists	n/a	n/a	n=28	n= 28

Taking into consideration the sample sizes resulting from administering the surveys to the three (3) professional groups across three (3) health authorities for both pre and post PACS implementation, the following four (4) groups were selected for further analysis with respect to the perceived benefits and challenges of PACS:

1. Physicians in the Terrier Health Authority 3 months pre PACS implementation (n=38), compared to physicians in the Terrier Health Authority 12 months post PACS implementation (n=43)

2. Radiology technologists in the Terrier Health Authority 3 months pre PACS implementation (n=18), compared to radiology technologists in the Terrier Health Authority 12 months post PACS implementation (n=28).

3. Physicians in the Terrier, Mastiff and Spaniel Health Authority's post PACS implementation (n=335), compared to radiologists in the Terrier, Mastiff and Spaniel Health Authority's post PACS implementation (n=27).

4. In comparing levels of agreement by previous experience with PACS it would not be appropriate to simply compare across health authorities, as there is considerable migration of physicians and radiologists in, out and between the authorities. The "experience" measure used for the study was based on the question in the post PACS survey "*Have you had experience with PACS prior to this implementation project?*" If the response was "Yes" to this question, a second question asked "*How many years of PACS experience have you had?*" Based on the responses to these two questions the categories of previous PACS experience used in the analysis were derived as follows: 1) no previous PACS experience, 2) >0 but <2 years previous PACS experience, and 3) ≥ 2 years previous PACS experience

4.2.5 Survey Response Summary

A summary of response rates for surveys administered to physicians, radiologists and radiology technologists pre and post PACS implementation is presented in Table 4-3. A detailed presentation of response rates by Health Authority and profession is presented in Appendix "K".

Table 4-3
Survey Response Summary: Pre and Post PACS
Mastiff, Spaniel and Terrier Health Authorities

Profession	Health Authority Pre PACS Implementation			Total
	Mastiff	Spaniel	Terrier	
Physicians	n/a	n/a	31.7% (38)	31.7% (38)
Radiologists	n/a	n/a	33.3% (2)	33.3% (2)
Technologists	n/a	n/a	40.0% (18)	40.0% (18)
Profession	**Health Authority Post PACS Implementation**			**Total**
	Mastiff	**Spaniel**	**Terrier**	
Physicians	36.9% (241)	35.2% (51)	35.0% (43)	36.3% (335)
Radiologists	54.1% (20)	28.6% (2)	83.3% (5)	58.7% (27)
Technologists	n/a	n/a	62.2% (28)	62.2% (28)

4.2.6 Survey Results: Demographics

Note: A detailed presentation of survey results by Health Authority and profession is presented in Appendix "L"

Pre and Post PACS Survey: Physicians - Terrier Health Authority

Distributions by gender, profession and years practicing for physicians in the Terrier Health Authority who responded to the pre and post PACS surveys, as well as available demographics for the total physician population for the Terrier Health Authority is presented in Table 4-4. For both the pre and post PACS survey the majority of responding physicians in the Terrier Health Authority were male (81.6% and 76.7%, respectively). There was a somewhat higher percentage of general practitioners responding to the pre PACS survey compared to the post PACS survey (52.6% versus 44.2%). A higher percentage of physicians who responded to the post PACS survey had 15 or less years practicing than those responding to the pre PACS survey (41.9% versus 26.3%). There was no statistically significant difference in the distributions of physicians by gender or profession for the total physician population, or for those that responded to both the pre and post PACS survey. As well, there was no significant difference in years practicing for physicians responding to the pre and post PACS survey.

Table 4-4
Physicians Demographics: Pre and Post PACS
Terrier Health Authority

Survey Question	Demographics Physicians					p-value[2]
	Population[1]	Pre PACS (n=38)		Post PACS (n=43)		
	N =123	n/% Respond	n/%	n/% Response	n/%	
Gender						
Male	98 (79.7%)	38 (100%)	31 (81.6%)	43 (100%)	33 (76.7%)	0.594
Female	25 (20.3%)		7 (18.4%)		10 (23.3%)	
Profession						
General Practitioner	77 (56.2%)	38 (100%)	20 (52.6%)	43 (100%)	19 (44.2%)	0.448
Specialist	60 (43.7%)		18 (47.4%)		24 (55.8%)	
Years Practicing						
≤ 15	n/a	38 (100%)	10 (26.3%)	43 (100%)	18 (41.9%)	0.221
16-20	n/a		10 (26.3%		6 (14.0%)	
≥ 21	n/a		18 (47.4%)		19 (44.2%)	

[1] Source: Newfoundland and Labrador Medical Association
[2] Chi-Square Test

Post PACS Survey: Physicians – All Health Authorities Combined

Distributions by gender, profession and years practicing for responding physicians for the post PACS surveys in the Terrier, Mastiff and Spaniel Health Authorities combined, as well as available demographics for the total physician population for these three health authorities are presented in Table 4-5. For the post PACS survey, the majority of responding physicians were male (72.3%), were specialists (71.6%), and were practicing for 20 years or less (72.0%). There was no statistically significant difference in the distributions of physicians by gender compared to the total physician population, although a significantly higher

(<0.001) percentage of specialists responded to the post PACS survey than that found in the overall physician population (71.6% versus 52.5%).

Table 4-5
Physicians Demographics: Post PACS
Terrier, Mastiff and Spaniel Health Authority (Combined)

Survey Question	Demographics: Physicians (Post PACS) Terrier, Mastiff and Spaniel Health Authorities (Combined)			p- value[2]
		Post PACS (n=335)		
	Population[1] N =1026	n/% Respond	n/% Response	
Gender				
Male	720 (70.2%)	332 (99.1%)	240 (72.3%)	0.584
Female	306 (29.8%)		92 (27.7%)	
Profession				
General Practitioner	490 (47.8%)	335 (100.0%)	95 (28.4%)	<0.001
Specialist	536 (52.2%)		240 (71.6%)	
Years Practicing				
≤ 15	n/a	334 (99.7%)	149 (44.6%)	n/a
16-20	n/a		58 (17.4%)	
≥ 21	n/a		127 (38.0%)	

[1] Source: Newfoundland and Labrador Medical Association
[2] Chi-Square Test

Post PACS Survey: Radiologists – All Health Authorities Combined

Distributions by gender and years practicing for responding radiologists for the post PACS surveys in the Terrier, Mastiff and Spaniel Health Authorities combined, as well as the available demographics for the total radiologist population for the three health authorities are presented in Table 4-6. For the post PACS survey, the majority of responding radiologists were male (66.7%) and were practicing for 20 years or less (68.0%). There was no statistically significant difference (p= 0.532) in the distribution of radiologists by gender compared to the total radiologist population.

Table 4-6
Radiologist Demographics: Post PACS
Terrier, Mastiff and Spaniel Health Authority (Combined)

Survey Question	Demographics: Radiologists (Post PACS) Terrier, Mastiff and Spaniel Health Authorities (Combined)			p-value[2]
		Post PACS (n=27)		
	Population[1] N =52	n/% Respond	n/% Response	
Gender				
Male	37 (71.2%)	27 (100.0%)	18 (66.7%)	0.532
Female	15 (28.8%)		9 (33.3%)	
Profession				
General Practitioner	n/a	27 (100.0%)	n/a	n/a
Specialist	53 (100.0%)		27 (100%)	
Years Practicing				
$\leq$ 15	n/a	27 (100.0%)	12 (48.0%)	n/a
16-20	n/a		6 (20.0%)	
$\geq$ 21	n/a		9 (32.0%)	

[1] Source: Newfoundland and Labrador Medical Association
[2] Chi-Square Test

Pre and Post PACS Survey: Radiology Technologists - Terrier Authority

Distributions by gender and years practicing for responding radiology technologists for the pre and post PACS surveys in the Terrier Health Authority are presented in Table 4-7. For both the pre and post PACS survey, the majority of responding radiology technologists were female (72.2% and 75.0%, respectively). There was no significant difference in the gender distribution for technologists in the Terrier Health Authority, and those responding to the pre and post PACS survey. A higher percentage of technologists responding to the pre PACS survey had more than 10 years experience compared to those responding to the post PACS survey (52.9% versus 39.3%, respectively), although this difference was not statistically significant (p=0.389).

Table 4-7
Radiology Technologists Demographics: Pre and Post PACS
Terrier Health Authority

Survey Question	Demographics Radiology Technologists					p-value[2]
	Population[1] N = 45	Pre PACS (n=18) n/% Respond	Pre PACS (n=18) n/% Response	Post PACS (n=28) n/% Respond	Post PACS (n=28) n/% Response	
Gender						
Male	12 (26.7%)	18 (100.0%)	5 (27.8%)	28 (100%)	7 (25.0%)	0.834
Female	33 (73.3%)		13 (72.2%)		21 (75.0%)	
Years Practicing						
≤ 2	n/a	17 (94.4%)	3 (17.6%)	28 (100%)	3 (10.7%)	0.389
2-10	n/a		5 (29.4%)		14 (50.0%)	
≥ 11	n/a		9 (52.9%)		11 (39.3%)	

[1] Source: Diagnostic Imaging Director - Terrier Health Authority
[2] Chi-Square Test

Physicians Film Environment Pre PACS Implementation: Terrier Health Authority

Table 4-8(A) presents indicator measures related to the physician's film environment prior to the implementation of PACS in the Terrier Health Authority. The majority of physicians used film for clinical assessment (63.2%), diagnosis (63.2%) and/or treatment (55.3%). Only a moderate percentage of physicians agreed they can always find film (59.5%) and/or reports (47.2%) when needed, with similar percentages satisfied with the amount of time it takes to retrieve film (58.8%) and reports (45.7%); 22.9% agreed their clinical schedule was sometimes delayed because of a problem in obtaining prior exams. A large majority of physicians agreed film (97.2%) and reports (97.2%) were important in managing patient care, and that historical reports (83.8%) were required more often in patient care than film (48.6%).

Table 4-8 (A)
Physicians Film Environment: Pre PACS Implementation
Terrier Health Authority

Survey Question	Physicians (n=38)	
	n/% Respond	n/% Response Frequently/Always
How often do you use film for:		
Clinical assessment	38 (100.0%)	24 (63.2%)
Clinical diagnosis	38 (100.0%)	24 (63.2%)
Clinical treatment	37 (97.4%)	21 (55.3%)
Professional education	32 (84.2%)	5 (13.2%)
Rounds	32 (84.2%)	5 (13.2%)
Patient education	31 (81.6%)	5 (13.2%)
Health services research	32 (84.2%)	2 (5.3%)
Survey Question	n/% Respond	n/% Response Moderate/Strong
To what extent do you agree with:		
I can always find film when I need it?	37 (97.4%)	22 (59.5%)
I can always find a report when I need it?	36 (94.7%)	17 (47.2%)
Survey Question	n/% Respond	n/% Response Often/Always
How often is your clinical schedule delayed because of a delay in obtaining prior exams?	35 (92.1%)	8 (22.9%)
Survey Question	n/% Respond	n/% Response Satisfied/Very Satisfied
How satisfied are you with the amount of time it takes to retrieve?		
Film	34 (89.5%)	20 (58.8%)
Reports	35 (92.1%)	16 (45.7%)
Survey Question	n/% Respond	n/% Response Satisfied/Very Satisfied
How important are the following in managing patient care?		
Film	36 (94.7%)	35 (97.2%)
Reports	36 (94.7%)	35 (97.2%)
Survey Question	n/% Respond	n/% Response Satisfied/Very Satisfied
How often do you look at historical:		
Film	37 (97.4%)	18 (48.6%)
Reports	37 (97.4%)	31 (83.8%)

Table 4-8(B) presents additional indicator measures related to the physician's film environment prior to the implementation of PACS in the Terrier Health Authority. Physicians spent an average of 16.2 minutes a day looking for film, 24.2 minutes looking for reports and 26.6 minutes per day managing and handling film. A further 45 minutes per week was spent traveling between sites. Historical film was felt to be needed for the patient care process 12 months or longer by 66.7% of physicians. Access to film and reports took place primarily in the Radiology Department (86.8% and 57.9%, respectively) and the physician's office (15.8% and 65.8%, respectively). There was limited access to film and reports from the physician's home office (2.6% and 7.9%, respectively). Physicians reported accessing reports (61.1%) more often than film (8.3%), while 30.6% reported they accessed film as much as they did reports.

Table 4-8 (B)
Physicians Film Environment: Pre PACS Implementation
Terrier Health Authority

Survey Question	Physicians (n=38)	
	n/% Respond	Response average (SD)
Average Time Spent per Day (Minutes)		
Looking for film?	19 (50.0%)	16.2 (11.4)
Looking for reports?	27 (71.1%)	24.2 (13.9)
Managing and handling films?	19 (50.0%)	26.6 (23.3)
Survey Question	n/% Respond	n/% Response > 12 Months
After how much time is a film no longer referred to in the patient care process?	15 (39.5%)	10 (66.7%)
Survey Question	n/% Respond	Response average (SD)
Estimate number of hours per week spent traveling between hospital sites?	18 (47.4%)	0.78 (1.5)
Survey Question	n/% Respond	n/% Response Yes
Currently access film/reports?		
Medical Imaging		
Film	38 (100%)	33 (86.8%)
Reports	38 (100%)	22 (57.9%)
Private Office		
Film	38 (100%)	6 (15.8%)
Reports	38 (100%)	25 (65.8%)
Home Office		
Film	38 (100%)	1 (2.6%)
Reports	38 (100%)	3 (7.9%)
Survey Question	n/% Respond	n/% Response Yes
What do you access most frequently?		
Film	36 (94.7%)	3 (8.3%)
Reports	36 (94.7%)	22 (61.1%)
Both	36 (94.7%)	11 (30.6%)

Perceived Benefits of PACS Pre-Implementation - Physicians in Terrier Health Authority

Table 4-9 presents the percent agreement physicians in the Terrier Health Authority had with the perceived benefits of PACS 3-months prior to the implementation of PACS, and again 12 months after PACS had been implemented.

Pre PACS Implementation Survey: Terrier

Three months prior to PACS being implemented in the Terrier Health Authority physicians strongly agreed PACS would reduce the time needed to review an exam (94.0%), enhance patient care in rural Newfoundland and Labrador (93.9%), and increase access to exams (90.9%). The lowest level of agreement was found with the statement that PACS would reduce length of patient stay in hospital (65.5%).

Post PACS Implementation Survey: Terrier

Twelve months following the implementation of PACS in the Terrier Health Authority, physicians strongly agree that PACS enhanced patient care in rural Newfoundland and Labrador (92.9%) and improved the quality of the report

(90.5%). Minimal agreement was found when physicians were asked if PACS had reduced length of patient stay in hospital (40.5%)

Perceived Benefits: Physicians - Pre Versus Post PACS Implementation: Terrier

As shown in Table 4-9, of the eleven indicators measuring perceived benefits pre and post PACS implementation in Terrier, the level of physician agreement decreased by an average of 10.0% post PACS for ten indicators. Of these indicators, the only statistically significant decrease was for the opinions of physicians if asked if PACS would reduce patient length of hospital stay (65.5% versus 40.5%: p = 0.044). There was no statistically significant difference found for the indicator which experienced an increase in percent of agreement from pre to post PACS (i.e., PACS tools and functionality has improved quality of the report (81.3% versus 90.5%: p = 0.250)).

Table 4-9
Physicians Perceived Benefits of PACS: Pre and Post PACS
Terrier Health Authority

Survey Question	Perceived Benefits of PACS Physicians				p-value[1]
	Pre PACS (n=38)		Post PACS (n=43)		
	n/% Respond	n/% Agree	n/% Respond	n/% Agree	
PACS will/has reduce(d) the time I must wait to review an exam	33 (86.8%)	31 (94.0%)	42 (97.7%)	37 (88.1%)	0.455*
I will/have access(ed) exams more frequently with PACS than film	33 (86.8%)	30 (90.9%)	43 (100%)	35 (81.4%)	0.331*
Report turn-around-times will/has improve(d) with PACS	33 (86.8%)	26 (78.8%)	41 (95.3%)	28 (68.3%)	0.312
PACS tools and functionality will/has improve(d) quality of the report	32 (84.2%)	26 (81.3%)	42 (97.7%)	38 (90.5%)	0.313*
PACS will/has facilitate(d) consultations with other clinicians/radiologists	33 (86.8%)	28 (84.8%)	42 (97.7%)	34 (81.0%)	0.658
My efficiency will/has improve(d) with PACS	33 (86.8%)	27 (81.8%)	43 (100%)	31 (72.1%)	0.323
PACS will/has improve(d) my ability to make decisions regarding patient care	33 (86.8%)	29 (87.9%)	41 (95.3%)	33 (80.5%)	0.530*
PACS will/has lead to reduced length of patient stay in hospital	29 (76.3%)	19 (65.5%)	37 (86.0%)	15 (40.5%)	0.044
PACS will/has lead to reduced patient transfers	30 (78.9%)	22 (73.3%)	35 (81.4%)	23 (65.7%)	0.507
PACS will/has lead to reduced exam re-orders	32 (84.2%)	27 (84.4%)	40 (93.0%)	26 (65.0%)	0.064
PACS will/has enhance(d) patient care in rural Newfoundland and Labrador	33 (86.8%)	31 (93.9%)	42 (97.7%)	39 (92.9%)	1.000*

[1] Chi-Square Test except where denoted by (*)
* Fisher's Exact Test

<u>Perceived Challenges of PACS: Physicians - Terrier Health Authority</u>

Table 4-10 presents the percent agreement physicians in the Terrier Health Authority had with the perceived challenges of PACS 3-months prior to the implementation of PACS, and 12 months after PACS had been implemented.

Pre PACS Implementation: Terrier

Three months prior to PACS being implemented in the Terrier Health Authority physicians moderately agreed (70.6%) that PACS would not allow for viewing of images at the patient's bedside. There was modest agreement that there would be a lack of system support (54.3%) and that PACS would produce inadequate image quality on the Web (51.5%). There was little agreement that PACS would result in difficulty in finding images (19.4%) or logging onto the system (19.4%).

Post PACS Implementation: Terrier

Twelve months following the implementation of PACS in the Terrier Health Authority physicians moderately agreed that PACS has not allowed for viewing of images at the patient's bedside (75.0%). There was little agreement that there is inadequate image quality on workstations (12.2%).

Perceived Challenges: Physicians Pre Versus Post PACS Implementation: Terrier

As shown in Table 4-10, of the eleven indicators measuring perceived challenges of PACS in Terrier, the level of physician agreement for seven indicators decreased an average of 14.7% from the pre to the post PACS survey. Of these indicators, the only statistically significant decrease was when physicians were asked if PACS will produce inadequate image quality on the workstation (36.4% versus 12.2%: p = 0.014). The average difference for the four indicator measures which experienced an increase in agreement from pre to post PACS was 4.5%. There was no statistically significant difference found for these four indicators, which were: 1) difficulty in finding images, 2) inadequate workstation performance, 3) difficulty in logging onto the PACS, and 4) unable to view images at the patient's bedside.

Table 4-10
Physicians Perceived Challenges of PACS: Pre and Post PACS
Terrier Health Authority

Survey Question	Perceived Challenges of PACS Physicians				p-value[1]
	Pre PACS (n=38)		Post PACS (n=43)		
	n/% Respond	n/% Agree	n/% Respond	n/% Agree	
PACS will/has produce(d) inadequate image quality on the Web	33 (86.8%)	17 (51.5%)	27 (62.8%)	10 (37.0%)	0.262
PACS will/has produce(d) inadequate image quality on workstations	33 (86.8%)	12 (36.4%)	41 (95.3%)	5 (12.2%)	0.014
I will (have) difficulty in finding images when needed	36 (94.7%)	7 (19.4%)	43 (100%)	11 (25.6%)	0.517
I will (have) experience(d) inadequate Web performance (speed)	34 (89.5%)	13 (38.2%)	42 (97.7%)	9 (21.4%)	0.108
I will (have) experience(d) inadequate workstation performance (speed)	34 (89.5%)	11 (32.4%)	42 (97.7%)	15 (35.7%)	0.759
I will (have) inadequate access to PACS viewing stations (Web or workstations)	36 (94.7%)	16 (44.4%)	42 (97.7%)	11 (26.2%)	0.091
I will (have) difficulty in logging onto the PACS	36 (94.7%)	7 (19.4%)	43 (100%)	10 (23.3%)	0.681
PACS downtime will/has be(en) higher than acceptable	35 (92.1%)	11 (31.4%)	41 (95.3%)	9 (22.0%)	0.350
I will/did receive inadequate training in the new technology	33 (86.8%)	12 (36.4%)	42 (97.7%)	14 (33.3%)	0.784
I will/have be(en) unable to view images at the patient's bedside.	34 (89.5%)	24 (70.6%)	36 (83.7%)	27 (75.0%)	0.678
I will/have experienced (d) lack of availability of system support	35 (92.1%)	19 (54.3%)	40 (93.0%)	15 (37.5%)	0.145

[1] Chi-Square Test

Perceived Benefits of PACS: Radiologists and Physicians – All Health Authorities Combined

Table 4-11 presents the percent agreement for perceived benefits of PACS post implementation for physicians and radiologists in the Terrier, Mastiff and Spaniel Health Authorities combined.

Post PACS Implementation – Physicians: All Authorities

Physicians strongly agreed that PACS reduced the time needed to review an exam (92.9%) and enhanced patient care in rural Newfoundland and Labrador (92.2%). There was minimal agreement that PACS reduced length of patient stay in hospital (44.2%).

Post PACS Implementation – Radiologists: All Authorities

All radiologists responding agreed that PACS has enhanced patient care in rural Newfoundland and Labrador (100.0%). There was also strong agreement that PACS has reduced the time needed to review an exam (96.3%) and improved their reporting and consultation efficiency (96.3%). There was minimal agreement that PACS increased the number of face to face consultations with other physicians (25.9%).

Post PACS Implementation - Physicians versus Radiologists: All Authorities

As shown in Table 4-11, of the five benefit measures that were presented to both physicians and radiologists, no significant difference was found in the percent agreement with respect to: PACS has reduced the time to review an exam (92.9% versus 96.3%: $p = 0.504$), exams are accessed more frequently with PACS than with film (86.3% versus 77.8%: $p = 0.229$), PACS improved the quality of report (81.6% versus 88.5%: $p = 0.383$), and that PACS has enhanced patient care in rural Newfoundland and Labrador (92.2% versus 100.0%: $p = 0.140$). There was a significant difference found between physicians and radiologists in the percent agreement that report turn-around-times has improved with PACS (71.1% versus 88.9%, respectively: $p = 0.047$).

Table 4-11
Physicians and Radiologists Perceived Benefits of PACS: Post PACS Terrier, Mastiff and Spaniel Health Authorities (Combined)

Survey Question	Perceived Benefits of PACS Post Implementation				p-value[1]
	Physicians (n=335)		Radiologists (n=27)		
	n/% Respond	n/% Agree	n/% Respond	n/% Agree	
PACS has reduced the time I must wait to review an exam	325 (97.0%)	302 (92.9%)	27 (100%)	26 (96.3%)	0.504
I have accessed exams more frequently with PACS than film	320 (95.5%)	276 (86.3%)	27 (100%)	21 (77.8%)	0.229
Report turn-around-time has improved with PACS	322 (96.1%)	229 (71.1%)	27 (100%)	24 (88.9%)	0.047
PACS tools and functionality has improved quality of the report	316 (94.3%)	258 (81.6%)	26 (96.3%)	23 (88.5%)	0.383
PAS has improved the quality and frequency of patient round involvement	n/a	n/a	24 (88.9%)	14 (58.3%)	n/a
PACS has increased the number of face to face consultations with other physicians	n/a	n/a	27 (100%)	7 (25.9%)	n/a
PACS has increased the number of phone consultations I have with other physicians	n/a	n/a	27 (100%)	19 (70.4%)	n/a
PACS has reduced my professional travel time	n/a	n/a	20 (74.1%)	10 (50.0%)	n/a
PACS has improved medical student and radiology resident teaching	n/a	n/a	21 (77.8%)	17 (81.0%)	n/a
With PACS, I now report remotely for sites to which I previously traveled	n/a	n/a	22 (81.5%)	10 (45.5%)	n/a
With PACS, I now report remotely for new sites	n/a	n/a	22 (81.5%)	13 (59.1%)	n/a
PACS has improved my reporting and consultation efficiency	n/a	n/a	27 (100%)	26 (96.3%)	n/a
PACS has facilitated consultations with other clinicians/radiologists	315 (94.0%)	266 (84.4%)	n/a	n/a	n/a
My efficiency has improved with PACS	329 (98.2%)	276 (83.9%)	n/a	n/a	n/a
PACS has improved my ability to make decisions regarding patient care	320 (95.5%)	256 (80.0%)	n/a	n/a	n/a
PACS has led to reduced length of patient stay in hospital	260 (77.6%)	115 (44.2%)	n/a	n/a	n/a
PACS has led to reduced patient transfers	262 (78.2%)	174 (66.4%)	n/a	n/a	n/a
PACS has led to reduced exam re-orders	302 (90.1%)	222 (73.5%)	n/a	n/a	n/a
PACS has enhanced patient care in rural Newfoundland and Labrador	296 (88.4%)	273 (92.2%)	26 (96.3%)	26 (100%)	0.140

[1] Chi-Square Test

Perceived Challenges of PACS: Radiologists and Physicians – All Health Authorities Combined

Table 4-12 presents the percent agreement for perceived challenges of PACS post implementation for physicians and radiologists in the Mastiff, Spaniel and Terrier Health Authorities combined.

Post PACS Implementation – Physicians: All Authorities

There was moderate agreement by physicians that the implementation of PACS was well managed (76.5%), and that PACS has not allowed for viewing of images at the patient's bedside (68.3%). There was little agreement that PACS caused difficulty in finding images when needed (19.6%).

Post PACS Implementation – Radiologists: All Authorities

There was moderate agreement among radiologists that the implementation of PACS was well managed (77.8%), and modest agreement that PACS provided inadequate Web performance (54.5%). There was little agreement that they have experienced difficulty in finding images when needed (11.1%), and that it has been difficult logging onto PACS (11.1%).

Post PACS Implementation - Physicians versus Radiologists: All Authorities

As shown in Table 4-12, of the eleven indicators measuring perceived challenges of PACS across all three Authorities, the level of agreement for eight indicators was higher for physicians than radiologists by an average of 9.5%. For the three indicators where radiologists' agreement was higher, the average difference was 8.9%. Only one indicator was found to be significantly different between the two groups; 54.5% of radiologists agreed that they have experienced inadequate Web performance (speed), while only 31.2% of physicians felt this was the case ($p=0.025$).

Table 4-12
Physicians and Radiologists Perceived Challenges of PACS: Post PACS Terrier, Mastiff and Spaniel Health Authorities (Combined)

Survey Question	Perceived Challenges of PACS Post Implementation				p-value[1]
	Physicians (n=335)		Radiologists (n=27)		
	n/% Respond	n/% Agree	n/% Respond	n/% Agree	
PACS produces inadequate image quality on the Web	196 (58.5%)	97 (49.5%)	20 (74.1%)	9 (45.0%)	0.702
PACS produces inadequate image quality on hospital workstations	302 (90.1%)	85 (28.1%)	26 (96.3%)	3 (11.5%)	0.067
PACS produces inadequate functionality on the Web	n/a	n/a	22 (81.5%)	10 (45.5%)	n/a
PACS produces inadequate functionality on workstations	n/a	n/a	26 (96.3%)	3 (11.5%)	n/a
I have difficulty in finding images when needed	317 (94.6%)	62 (19.6%)	27 (100%)	3 (11.1%)	0.282
I have experienced inadequate Web performance (speed)	285 (85.1%)	89 (31.2%)	22 (81.5%)	12 (54.5%)	0.025
I have experienced inadequate workstation performance (speed)	305 (91.0%)	88 (28.9%)	27 (100%)	6 (22.2%)	0.464
I have inadequate access to PACS viewing station	318 (94.9%)	93 (29.2%)	27 (100%)	4 (14.8%)	0.109
I have difficulty in logging onto the PACS	322 (96.1%)	69 (21.4%)	27 (100%)	3 (11.1%)	0.203
PACS downtime has been higher than acceptable	322 (96.1%)	69 (21.4%)	26 (96.3%)	5 (19.2%)	0.792
I received insufficient training in the new technology	317 (94.6%)	149 (47.0%)	26 (96.3%)	9 (34.6%)	0.223
I have been unable to view images at the patient's bedside.	268 (80.0%)	183 (68.3%)	n/a	n/a	n/a
I have experienced a lack of availability of system support	295 (88.1%)	103 (34.9%)	27 (100%)	10 (37.0%)	0.825
The implementation/installation from film to PACS was well managed	293 (87.5%)	224 (76.5%)	27 (100%)	21 (77.8%)	0.876

[1] Chi-Square Test

<u>Perceived Benefits and Challenges of PACS by Previous Experience with PACS: Physicians - All Health Authorities Combined: Post PACS</u>

Table 4-13 presents the percent agreement of perceived benefits of PACS post implementation by physicians in the Terrier, Mastiff, and Spaniel Health Authorities combined based on previous experience with PACS.

Perceived Benefits Post PACS: Physicians - No Previous PACS Experience

Physicians with no previous experience with PACS prior to the Infoway investment strongly agreed that PACS enhanced patient care in rural Newfoundland and Labrador (93.0%), and reduced the time needed to review an exam (90.0%). There was minimal agreement that PACS had reduced length of patient stay in hospital (36.1%).

Perceived Benefits Post PACS: Physicians - $<$ 2 Years Previous PACS Experience

Physicians with $<$ 2 years previous experience with PACS prior to the Infoway investment strongly agreed that PACS reduced the time needed to review an exam (95.6%), and enhanced patient care in rural Newfoundland and Labrador (92.9%). There was modest agreement that PACS reduced length of patient stay in hospital (50.0%).

Perceived Benefits Post PACS: Physicians- $\geq$ 2 Years Previous Experience

Physicians with $\geq$ 2 years previous experience with PACS prior to the Infoway investment strongly agreed that PACS reduced the time needed to review an exam (92.6%), and enhanced patient care in rural Newfoundland and Labrador (91.9%).

There was minimal agreement that PACS had reduced the length of patient stay in hospital (43.5%).

Perceived Benefits Post PACS: Physicians - No Previous Experience versus <2 Years versus ≥ 2 Years

Of the eleven indictors measuring the perceived benefits of PACS, two were found to have a significant difference in levels agreement across the three categories of previous PACS experience. When asked if their efficiency has improved with PACS, 73.1% of physicians with no previous experience agreed, while 87.8% with <2 years experience, and 88.5% with ≥ 2 years experience felt this was the case ($p = 0.022$). When asked if PACS has improved their ability to make decisions regarding patient care, 68.8% of physicians with no previous experience with PACS agreed, while 85.9% with <2 years experience, and 80.6 % with ≥ 2 years experience, felt this was the case ($p = 0.026$).

Table 4-13
Physicians Perceived Benefits of PACS by Previous Experience: Post PACS Terrier, Mastiff and Spaniel Health Authorities (Combined)

Survey Question	Physicians (n=335) Perceived Benefits of PACS by Previous Experience						P value[1]
	No Experience (n=54)		‹ 2 PACS Experience (n=93)		≥ 2 PACS Experience (n=180)		
	n/% Respond	n/% Agree	n/% Respond	n/% Agree	n/% Respond	n/% Agree	
PACS has reduced the time I must wait to review an exam	50 (92.6%)	45 (90.0%)	91 (97.8%)	87 (95.6%)	176 (97.8%)	163 (92.6%)	0.727 *
I have accessed exams more frequently with PACS than film	49 (90.7%)	39 (79.6%)	91 (97.8%)	81 (89.0%)	173 (96.1%)	150 (86.7%)	0.294
Report turn-around-time has improved with PACS	49 (90.7%)	31 (63.3%)	89 (95.7%)	66 (74.2%)	176 (97.8%)	128 (72.7%)	0.355
PACS tools and functionality has improved quality of the report	47 (87.0%)	40 (85.1%)	89 (95.7%)	74 (83.1%)	172 (95.6%)	138 (80.2%)	0.692
PACS has facilitated consultations between me and other clinicians/radiologists	46 (85.2%)	42 (91.3%)	88 (94.6%)	73 (83.0%)	174 (96.7%)	146 (83.9%)	0.643 *
My efficiency has improved with PACS	52 (96.3%)	38 (73.1%)	92 (98.9%)	79 (87.8%)	174 (96.7%)	154 (88.5%)	0.022
PACS has improved my ability to make decisions regarding patient care	48 (88.9%)	33 (68.8%)	90 (96.8%)	79 (85.9%)	175 (97.2%)	141 (80.6%)	0.026
PACS has led to reduced length of patient stay in hospital	36 (66.7%)	13 (36.1%)	70 (75.3%)	35 (50.0%)	147 (81.7%)	64 (43.5%)	0.380
PACS has led to reduced patient transfers	38 (70.4%)	23 (60.5%)	70 (75.3%)	47 (67.1%)	147 (81.7%)	100 (68.0%)	0.679
PACS has led to reduced exam re-orders	46 (85.2%)	32 (69.6%)	80 (86.0%)	56 (70.0%)	169 (93.9%)	129 (76.3%)	0.457
PACS has enhanced patient care in rural Newfoundland and Labrador	43 (79.6%)	40 (93.0%)	85 (91.4%)	79 (92.9%)	161 (89.4%)	148 (91.9%)	0.740 *

[1] Chi-Square Test except where denoted by (*)

* Fisher Exact Test Used (2x3: http://www.physics.csbsju.edu/cgi-bin/stats/)

Table 4-14 presents the percent agreement of perceived challenges of PACS post implementation by previous experience with PACS for physicians in the Terrier, Mastiff, and Spaniel Health Authorities combined.

Perceived Challenges Post PACS: Physicians - No Previous PACS Experience

There was strong agreement by physicians with no previous experience with PACS that the implementation of PACS was well managed (83.7%), and moderate agreement that PACS has not allowed for viewing of images at the patient's bedside (71.1%). There was little agreement that PACS resulted in challenges in logging onto the system (18.8%).

Perceived Challenges Post PACS: Physicians - < 2 Years Previous Experience

There was strong agreement by physicians with < 2 years previous experience with PACS that the implementation of PACS was well managed (81.9%), and modest agreement that PACS has not allowed for viewing of images at the patient's bedside (58.0%). There was little agreement that PACS had unacceptable downtime (19.5%).

Perceived Challenges Post PACS: Physicians $\geq$ 2 Years Previous Experience

There was moderate agreement by physicians with $\geq$ 2 years previous experience with PACS that the implementation of PACS was well managed (71.9%), and modest agreement that PACS has not allowed for viewing of images at the patient's bedside (58.0%). There was little agreement that PACS had unacceptable downtime (19.5%).

Perceived Challenges: Physicians - No Previous Experience versus <2 years versus $\geq$ 2 Years

As shown in Table 4-14, of the eleven indicators measuring the perceived challenges of PACS post implementation, only one was found to have significantly different levels of agreement across the three categories of PACS experience. When asked if they had experienced inadequate Web performance (speed), 40.5% of physicians with no previous experience agreed, while 15.9% with <2 years experience, and 36.1% with $\geq$ 2 years experience felt this was the case ($p = 0.002$).

Table 4-14
Physicians Perceived Challenges of PACS by Previous Experience: Post PACS Terrier, Mastiff and Spaniel Health Authorities (Combined)

Survey Question	Physicians (n=335) Perceived Challenges of PACS by Previous Experience with PACS						p value[1]
	No Previous Experience (n=54)		‹ 2 PACS Experience (n=93)		≥ 2 PACS Experience (n=180)		
	n/% Respond	n/% Agree	n/% Respond	n/% Agree	n/% Respond	n/% Agree	
PACS produces inadequate image quality on the Web	30 (55.6%)	15 (50.0%)	56 (60.2%)	23 (41.1%)	107 (59.4%)	57 (53.3%)	0.333
PACS produces inadequate image quality on hospital workstations	46 (85.2%)	13 (28.3%)	82 (88.2%)	18 (22.0%)	167 (92.8%)	50 (29.9%)	0.411
I have difficulty in finding images when needed	46 (85.2%)	11 (23.9%)	91 (97.8%)	16 (17.6%)	173 (96.1%)	31 (17.9%)	0.617
I have experienced inadequate Web performance (speed)	42 (77.8%)	17 (40.5%)	82 (88.2%)	13 (15.9%)	155 (86.1%)	56 (36.1%)	0.002
I have experienced inadequate workstation performance (speed)	44 (81.5%)	13 (29.5%)	89 (95.7%)	22 (24.7%)	166 (92.2%)	51 (30.7%)	0.596
I have inadequate access to PACS viewing station	48 (88.9%)	17 (35.4%)	87 (93.5%)	19 (21.8%)	177 (98.3%)	56 (31.6%)	0.161
I have difficulty in logging onto the PACS	48 (88.9%)	9 (18.8%)	91 (97.8%)	20 (22.0%)	176 (97.8%)	37 (21.0%)	0.905
PACS downtime has been higher than acceptable	49 (90.7%)	16 (32.7%)	87 (93.5%)	17 (19.5%)	179 (99.4%)	35 (19.6%)	0.123
I received insufficient training in the new technology	48 (88.9%)	27 (56.3%)	89 (95.7%)	41 (46.1%)	174 (96.7%)	77 (44.3%)	0.334
I have been unable to view images at the patient's bedside.	39 (81.3%)	28 (71.8%)	81 (87.1%)	47 (58.0%)	155 (86.1%)	104 (67.1%)	0.243
I have experienced a lack of availability of system support	41 (79.6%)	11 (26.8%)	84 (90.3%)	29 (34.5%)	165 (91.7%)	61 (37.0%)	0.474
The implementation from film to PACS was well managed	43 (79.6%)	36 (83.7%)	83 (89.2%)	68 (81.9%)	160 (88.9%)	115 (71.9%)	0.104

[1] Chi-Square Test

Perceived Benefits and Challenges of PACS by Previous Experience with PACS: Radiology Technologists – Terrier Health Authority

Perceived Benefits: Radiology Technologists - Pre PACS Implementation

Only 2 of the 11 questions in the questionnaire specific to the benefits of PACS were relevant to radiology technologists. All radiology technologists responding (100.0%) in the Terrier Health Authority to the pre PACS implementation survey agreed that report turn-around-times will improve with PACS and that PACS will enhance patient care in rural Newfoundland and Labrador.

Perceived Benefits: Radiology Technologists - Post PACS Implementation

All radiology technologists responding (100.0%) 12 months following the implementation of PACS agreed that PACS enhances patient care in rural Newfoundland and Labrador. A majority agreed turn-around-times improved with PACS (92.6%). There was no significant difference in the level of agreement pre and post PACS for these two measures.

Table 4-15 presents the percent agreement of perceived benefits pre and post implementation PACS for radiology technologists in the Terrier Health Authority.

Table 4-15
Radiology Technologists Perceived Benefits of PACS: Pre and Post PACS Terrier Health Authority

Survey Question	Perceived Benefits of PACS Radiology Technologists				p-value[1]
	Pre PACS (n=18)		Post PACS (n = 28)		
	n/% Respond	n/% Agree	n/% Respond	n/% Agree	
Report turn-around-time will/has improve(d) with PACS	16 (88.9%)	16 (100.0%)	27 (96.4%)	25 (92.6%)	0.265
PACS will/has enhance(d) patient care in rural Newfoundland and Labrador	17 (94.4%)	17 (100.0%)	25 (89.3%)	25 (100%)	1.000

[1] Chi-Square Test

Perceived Challenges: Radiology Technologists - Pre PACS Implementation

Only 8 of the 11 questions in the questionnaire specific to the challenges of PACS were relevant to radiology technologists. Three months prior to PACS being implemented in the Terrier Health Authority a modest majority (56.3%) of radiology technologists agreed that they will have inadequate access to PACS viewing stations. There was little agreement that they will experience difficulty in finding images in PACS when needed (6.7%), or have difficulty in logging onto the PACS (0.0%).

Perceived Challenges: Radiology Technologists - Post PACS Implementation

Twelve months following the implementation of PACS in the Terrier Health Authority the majority of radiology technologists agreed that the implementation of PACS was well managed (85.7%). A moderate majority of radiology technologists agreed that PACS has resulted in inadequate workstation performance (speed) (59.3%). There was little agreement that they had difficulty in logging onto the PACS (7.1%), received inadequate training (7.1%), or that PACS provided inadequate image quality on workstations (0.0%).

Challenges of PACS: Pre and Post PACS Implementation

As shown in Table 4-16, of the 8 indicators which measured the perceived challenges of PACS to radiology technologists, 5 had a higher percentage pre PACS, whereas 3 had a higher percentage post PACS. The average difference for the 3 indicator measures which had a higher percentage post PACS was 15.7%, whereas the average difference for the 5 indicator measures which had a higher percentage pre PACS was 20.6%. Three of these indicators were found to be statistically significant difference between the pre and post PACS surveys: PACS produced inadequate image quality on workstations (21.4% versus 0.0%: p = 0.032), inadequate workstation performance (speed) (20.0% versus 59.3%: p =

0.015), and inadequate access to PACS viewing stations (Web or workstations) (56.3% versus 8.3%: p = 0.001).

Table 4-16 presents the percent agreement of perceived challenges pre and post implementation PACS for radiology technologists in the Terrier Health Authority.

Table 4-16
Radiology Technologists Perceived Challenges of PACS: Pre and Post PACS Terrier Health Authority

Survey Question	Perceived Challenges of PACS Radiology Technologists				p-value[1]
	Pre PACS (n=18)		Post PACS (n = 28)		
	n/% Respond	n/% Agree	n/% Respond	n/% Agree	
PACS will/has produce(d) inadequate image quality on workstations	14 (77.8%)	3 (21.4%)	28 (100%)	0 (0.0%)	0.032
I will (have) difficulty in finding images in PACS when I need them	15 (83.3%)	1 (6.7%)	27 (96.4%)	2 (7.4%)	0.713
I will (have) experience(d) inadequate workstation performance (speed)	15 (83.3%)	3 (20.0%)	27 (96.4%)	16 (59.3%)	0.015
I will (have) inadequate access to PACS viewing stations (Web or workstations)	16 (88.9%)	9 (56.3%)	24 (85.7%)	2 (8.3%)	0.001
I will (have) difficulty in logging onto the PACS	16 (88.9%)	0 (0.0%)	28 (100.0%)	2 (7.1%)	0.400
PACS downtime will/has be(en) higher than acceptable	16 (88.9%)	2 (12.5%)	28 (100.0%)	3 (10.7%)	0.608
I will/did receive inadequate training in the new technology	16 (88.9%)	4 (25.0%)	28 (100.0%)	2 (7.1%)	0.311
I will/have experience (d) lack of availability of system support	16 (88.9%)	4 (25.0%)	27 (96.4%)	3 (11.1%)	0.220
The implementation/installation from film to PACS was well managed	n/a	n/a	28 (100.0%)	24 (85.7%)	n/a

[1] Fisher Exact Test

Open Ended Question

Table 4-17 presents the number of respondents providing comments to the open-ended question on the pre and post PACS questionnaires. A higher percentage of respondents provided comments for the post PACS survey (38.1%), than the pre PACS survey (27.6%). The highest number of comments were provided by physicians responding to the post PACS survey (n=129), which made up 87.1% of all post PACS respondent comments.

Table 4-17
Survey Respondents Including Comments

Implementation	Responding to Survey	Included Comments	% Comments
Pre PACS	Terrier Health Authority		
Physicians	38	9	23.7
Radiologists	2	2	100.0
Technologists	18	5	27.8
Total	**58**	**16**	**27.6**
Post PACS	Terrier, Mastiff and Spaniel		
Physicians	335	129	38.8
Radiologists	25	11	44.0
Technologists	28	8	28.6
Total	**388**	**148**	**38.1**

Table 4-18 presents a summary of the comments provided by respondents to the survey. This summary is not meant to be objective; rather it serves as a high level subjective categorization of all views expressed in the comments, whether positive or negative. In preparing Table 4-18, recognizing that some respondents presented different views within the same comment, if a comment contained both positive and negative views, the researcher determined whether the comment was more positive or negative.

Within this context, the opportunity to express positive comments was taken up by 68.8% (11/16) of respondents in the pre PACS survey, and 48.0% (71/148) in the post PACS survey. (Note: the pre PACS survey was administered only to the Terrier Health Authority, whereas the post PACS survey was administered to all three Authorities. This accounts for the smaller sample of pre PACS comments). Of particular interest to the researcher were comments made by eight (8) physicians responding to the post PACS survey, in which several expressed displeasure with the questionnaire. While not relevant specifically to PACS, they are nevertheless provided immediately following Table 4-18.

Table 4-18
Summary of Type of Comment Provided

Implementation	Comments	Mostly Negative	Mostly Positive	Not Relevant	% Positive
Pre PACS					
Physicians	9	4	5	0	55.6%
Radiologists	2	0	2	0	100.0%
Technologists	5	1	4	0	80.0%
Totals	**16**	**5**	**11**	**0**	**68.8%**
Post PACS					
Physicians	129	57	64	8	49.6%
Radiologists	11	7	4	0	36.4%
Technologists	8	5	3	0	37.5%
Total	**148**	**69**	**71**	**8**	**48.0%**

<u>Physician Comments **Not** Relevant to PACS</u>

Complete anonymity of this survey is not at all insured

Why in this day and age are passwords case sensitive? Tell someone to get a life.

Very badly formatted questionnaire. Should have been done better to get all the info you are looking for.

Should have taken a closer look at the questionnaire before it was sent out, typos etc.

Section II needs no change between moderately disagree and moderately agree

Not sure why received this, as I only access PACS through review with radiologist. Most questions I felt were not applicable to me

May be missing questions, numbers don't correspond to available questions.

Many questions irrelevant to me

Physicians Comments Relevant to PACS

Table 4-19 presents the distribution of comments made by physicians with respect to the PACS implementation. The comments are categorized as either challenges or benefits of PACS, and are presented for both pre and post PACS implementation.

Given some physicians provided more than one view of PACS within the same comment, the total number of views is greater than the total number of comments. For example, if a physician expressed both a positive and a negative view in the same comment, then two separate views were recorded for this comment. The overall percentages presented at the bottom of Table 4-19 are based on the total number of views identified within the comments.

Nine physicians provided comments (total views = 9) for the pre PACS survey; 4 of the 9 views (44.4%) expressed in the comments identified access to PACS, whether at the inpatient or clinic environment, was expected to be a challenge. One-hundred and twenty-nine physicians provided 145 separate views for the post PACS survey. The issue of access was also found in the post PACS physician survey, with the majority of views (n=42) identified as challenges being related to access (29.0%). This was followed by lack of quality PACS monitors (13.1%) and inadequate training (6.9%). Of the total views expressed, 30.3% were specific to benefits, whereas 69.7% were related to challenges.

Table 4-19
Summary Content of Physician Comments
Pre and Post PACS Survey

Pre PACS Implementation Physician Comments (n = 9)			
Perceived Benefit	**n (%)**	**Perceived Challenge**	**n (%)**
Can't Wait!!	2 (22.2%)	Access to PACS	4 (44.4%)
Reduced TAT	1 (11.1%)	Training	1 (11.1%)
Improve Consultations	1 (11.1%)		
Pre PACS Benefit Views = 4 (44.4%)		**Pre PACS Challenge Views = 5 (55.6%)**	
Post PACS Implementation Physician Comments (n = 129)			
Overall positive comments, including terms 'excellent', 'great', 'terrific', 'appreciated', 'wow', good, marvelous, 'wonderful', 'outstanding', 'thank you', 'terrific' and 'impressive'	44 (30.3%)	Access to PACS • Home/Office 21 (14.5%) • Rural Sites 14 (9.7%) • Within Hospital 7 (4.8%)	42 (29.0%)
		Access to PACS Monitors	19 (13.1%)
		Inadequate training	10 (6.9%)
		Access to prior exams	9 (6.2%)
		Downtime unacceptable	8 (5.5%)
		System Slow	7 (4.8%)
		Other	6 (4.1%)
Post PACS Benefit Views = 44 (30.3%)		**Post PACS Challenge Views 101 (69.7%)**	

Comments: Radiologists

Table 4-20 presents the distribution of comments made by radiologists with respect to the PACS implementation. The two radiologists who provided comments (views = 3) for the pre PACS survey both expected an increase in efficiency once PACS was implemented. There were no expected challenges expressed by radiologists in the pre PACS survey. Of the eleven (11) radiologists providing comments (views = 16) for the post PACS survey, three views (18.8%) noted that PACS was a significant improvement over the film environment. There were five challenges expressed by radiologists, with the top three being limited access to PACS monitors (25.0%), system is slow (18.8%), and inadequate IT support (18.8%).

Table 4-20
Summary Content of Radiologists Comments
Pre and Post PACS Survey

Pre PACS Implementation Radiologist Comments (n = 2)			
Perceived Benefit	**n (%)**	**Perceived Challenge**	**n (%)**
Increased Efficency	3 (100.0%)		
Pre PACS Benefit Views = 3 (100.0%)		**Pre PACS Challenge Views = 0 (0%)**	
Post PACS Implementation Radiologist Comments (n = 11)			
Significant Improvement	3 (18.8%)	Access to PACS Monitors	4 (25.0%)
		Slow System	3 (18.8%)
		Inadequate IT Support	3 (18.8%)
		Missing Archives	2 (12.5%)
		Inadeqaute Training	1 (6.3%)
Post PACS Benefit Views = 3 (18.8%)		**Post PACS Challenge Views = 13 (81.2%)**	

<u>Comments: Radiology Technologists</u>

Table 4-21 presents the distribution of comments made by radiology technologists with respect to the PACS implementation. Five technologists provided comments for the pre PACS survey, expressing a total of 7 views. In 3 of the views (42.9%), technologists' expressed high expectations that PACS will be an improvement over the film environment. Perceived challenges identified pre PACS included system downtime, and inadequate training and IT support. Eight technologists provided comments for the post PACS survey, expressing 9 separate views. Of these, three (33.3%) were very positive of PACS, while three (33.3%) expressed challenges with the PACS being slow.

Table 4-21
Summary Content of Technologists Comments
Pre and Post PACS Survey

Pre PACS Implementation Technologist Comments (n = 5)			
Perceived Benefit	**n (%)**	**Perceived Challenge**	**n (%)**
More efficient	1 (14.3%)	System Downtime	1 (14.3%)
High expetcations	3 (42.9%)	Inadequate Training	1 (14.3%)
		Inadequate IT Support	1 (14.3%)
Pre PACS Benefit Views = 4 (57.1%)		**Pre PACS Challenge Views = 3 (42.9%)**	
Post PACS Implementation Technologist Comments (n = 8)			
Great system, Love it, Wonderful	3 (33.3%)	System Slow	3 (33.3%)
		Poor Image Quality	1 (11.1%)
		Scanning requisition	1 (11.1%)
		Access to old exams	1 (11.1%)
Post PACS Benefit Views 3 (33.3%)		**Post PACS Challenge Views 6 (67.7%)**	

4.3 Administrative Data

Table 4-22 presents a summary of administrative data that was found to be available in the Mastiff and Terrier Health Authorities for the 12 benefit indicators proposed by Canada Health Infoway.

Table 4-22
Summary of Data Availability for
Twelve (12) Infoway Benefit Indicators

Data Available ✔ Data Not Available ✗	
1) Degree of Filmlessness	✔
2) Percentage digitally stored exams	✔
3) Number of unique clinician user accounts	✗
4) Number of active users	✗
5) Number of remote (e.g. VPN) users	✔*
6) Exam end to dictation end turn-around-time	✗
7) Total cycle turn-around-time	✔**
8) Worked productivity %	✗
9) Exams dictated per radiologist scheduled hours	✗
10) Unnecessary duplicate exams ratio	✗
11) Patient transfers	✗
12) Cost per exam	✔

* Proxy Measure
* *Modified TAT

Results for the twelve benefit indicators identified by Canada Health Infoway are presented below under six (6) benefit areas: 1) increased user adoption, 2) decreased utilization (duplicate tests), 3) improved productivity, 4) improved turn-around-time, 5) reduced patient transfers, and 6) cost per exam.

1. Increased User Adoption

Degree of Filmlessness

Degree of filmlessness is measured as the percentage of exams within scope completed and stored digitally 30 days following the implementation of PACS. Modalities within scope included ultrasound, computed tomography (CT Scan), magnetic resonance imaging (MRI), nuclear medicine, general radiography, and echocardiography. All modalities in the Terrier Health Authority achieved 95% digitally stored exams within 30 days of PACS being implemented. PACS sites within the Mastiff Health Authority reported 100% digitally stored exams was achieved by August 2005, one month after implementation.

Percent Digitally Stored Exams

The percent of digitally stored exams is collected monthly and shows the trend of conversion from exams archived on film to exams reported on PACS and archived to the data centre. Given all modalities within scope at the Terrier and Mastiff Health Authority's achieved at least 95% filmlessness 30 days after PACS was implemented, this measure provided no further information beyond the first month of implementation.

Number of Unique Clinician User Accounts

A measure of the number of clinicians provided access to the PACS system each month for 9 months following implementation. Data for this indicator was not available for several reasons. In the Terrier Health Authority, the IT Department at Hospital_A, the main hospital in the region, could not provide unique user accounts by site or user type (e.g., physician versus administration). Further, PACS sites in the Mastiff Authority could not provide data on this indicator given access would have been approved two years prior to data being requested and historical data on user accounts was not available. It was also determined that access and usage is only monitored at the HIS level, of which PACS is only one of many information systems available to the user. As such, it was not possible to obtain utilization statistics for PACS in isolation of other systems available through the HIS.

Number of Active Users

This indicator is a measure of the number of active PACS users each month for 9 months post PACS implementation. As with the indicator "Number of Unique Clinician User Accounts", it was not possible to obtain statistics on active users of PACS in isolation of other information systems accessed through the HIS.

Number of Remote Users

This indicator measures the number of users accessing PACS from outside the hospital (e.g., home or office). The data needed to identify users logged onto PACS was not available from hospitals in the Terrier and Mastiff Health Authorities (see Number of Active Users). As a proxy, the total number of requests for remote access to the Hospital Information System (HIS) to the IT Department at Hospital_A in Terrier was provided as of March 31, 2007.

Total Physicians in Terrier Authority	125 (100.0%)
Total Requesting Access only from office	34 (27.2%)
Total Requesting Access from office and home	5 (4.0%)

Total physicians in Terrier Health Authority requesting remote access to the HIS approximately 15 months post PACS implementation was 39, or 31.2% (39/125)

2. Decreased Utilization (duplicate exams)

Unnecessary Duplicate Exams

This indicator is a measure of impact that PACS has on the number of duplicate exams ordered because of a lack of exam availability when required. Data for this measure was not available from PACS hospitals in the Mastiff and Terrier Health Authorities because the order entry module for radiology in the HIS overwrites previous exam orders. Administrative data for this measure would also be limited in that the reason for the test order is not captured at point of order, and therefore would not indicate that the order was a duplicate.

3. Improved Productivity

Exams Dictated Per Radiologist Scheduled Hours

The purpose of this indicator is to measure the impact of PACS on the productivity of radiologists by calculating the number of exams read per FTE radiologist per hours worked in the film and PACS environments for each month 3 months pre PACS and for 9 months post PACS. Data for this indicator was not available. In Newfoundland and Labrador all radiologists are they paid on a fee for service basis; no data is systematically collected that identifies the total number of exams read or the hours scheduled or worked.

Worked Productivity Percent

This indicator is a measure of productivity for unit-producing personnel (UPP) within the radiology department, and was to be collected from the Radiology Information System (RIS) and the Management Information System (MIS) for each month 3 months pre PACS and for 9 months post PACS. Data for this indicator was not used given the poor quality of workload measurement data for radiology submitted to CIHI from hospitals in Newfoundland and Labrador. The issue of poor data quality was confirmed by the Director of Data Quality and Standards at the Centre for Health Information (personal communication to researcher June 15, 2006).

4. Improved Turn-Around-Time (TAT)

Exam End to Dictation End TAT

This indicator is a measure of the impact on the average time needed from exam completion to when the report has been dictated by the radiologist. It is the sum of the dictation completion time minus the exam completion time, divided by the total number of exams. Administrative data for this measure was not available from PACS hospitals in the Terrier Health Authority, because the dictation systems were stand alone systems at the time of the study. (i.e., not interfaced with the Radiology Information System). Therefore, the dictation start and completion times were not available.

Report Total Turn-Around-Time

This indicator is a measure of the impact that PACS has on the time taken from patient registration to when the radiologist's signed off (i.e., final) report was available to the referring physician for patient care. This measure was not used in this study because: 1) in some cases physicians utilized exams or draft reports for patient care, thus minimizing the need of the radiologists to verify these reports in a timely manner, 2) some radiologists were known to verify all reports generated over an extended period of time on a set day (e.g., every Friday afternoon), and 3) check-in time was captured differently for inpatients and outpatients. All inpatient "registrations" were recorded at 8:00 a.m. the morning after the physician had requested the exam. Conversely, outpatient "registrations" were recorded as the actual time the person registered in the hospital's radiology department.

Given the problems associated with both turn-around-time (TAT) measures proposed by Canada Health Infoway, a modified TAT measure was developed by the researcher that could be supported by administrative data in both the Mastiff and Terrier Health Authorities. This measure excluded inpatient exams, and used the average monthly TAT for exams originating at outpatient registration (i.e., from when the patient registered to when the unverified report was posted on the HIS). Data for this measure was collected for all modalities in scope (i.e., CT Scan, echocardiography, magnetic resonance imaging (MRI), nuclear medicine, general radiograph and ultrasound) from PACS hospitals in the Terrier and Mastiff Health Authorities. In most cases the collection period encompassed three (3) months pre PACS implementation and nine (9) months post PACS implementation.

TAT: Terrier Health Authority

Administrative data for all unverified report turn-around-times (TAT) for outpatients was collected from the Radiology Information System (RIS) and the Hospital Information System (HIS) for each modality within scope in the Terrier Health Authority from September 2005 to December 2006 (N = 112,667). As a result of staggered implementation dates for PACS at the 7 sites in the Terrier Health Authority, not all sites had complete data for 3 months pre and 9 months post PACS implementation. A summary of total exams and data collection periods by modality and site for the Terrier Health Authority is presented in Table 4-23.

Table 4-23
Exam Total by Modality and Site
Terrier Health Authority

Site	Modality	Time Frame	Total Exams
Hospital_A	Cat Scan	Sept 2005 – Dec 2006	9,831
	Echocardiography	Sept 2005 – Dec 2006	1,689
	MRI	Sept 2005 – Dec 2006	6,472
	Nuclear Medicine	Sept 2005 – Dec 2006	3,646
	General Radiograph	Sept 2005 – Dec 2006	46,041
	Ultrasound	Sept 2005 – Dec 2006	9,977
		Total Exams	**77,656**
Hospital_B	General Radiograph	Nov 2005 – Dec 2006	13,846
	Ultrasound	Nov 2005 – Dec 2006	2,881
		Total Exams	**16,727**
Hospital_D	General Radiograph	Sept 2005 – Dec 2006	5,864
	Ultrasound	Sept 2005 – Dec 2006	1,452
		Total Exams	**7,316**
Hospital_G	General Radiograph	Sept 2005 – Dec 2006	5,963
		Total Exams	**5,963**
Hospital_F	General Radiograph	Feb 2006 – Dec 2006	1,134
		Total Exams	**1,134**
Hospital_E	General Radiograph	Feb 2006 – Dec 2006	1,667
		Total Exams	**1,667**
Hospital_C	General Radiograph	Mar 2006 – Dec 2006	2,204
		Total Exams	**2,204**
		Total Exams Within Scope for all Sites	**112,667**

Table 4-24 presents the summary of the tests of significance for the monthly average turn-around-time (TAT) for sites in the Terrier Health Authority by modality for pre and post PACS implementation. Detailed descriptions of TATs for the Terrier Health Authority, by modality and site, are presented in Appendix "M".

Table 4-24
Average Monthly TAT by Modality and Site
Terrier Health Authority

Site	Modality	Average Monthly TAT		p-value
		Pre PACS	Post PACS	
Hospital_A	Cat Scan	75.3	121.7	<0.001
	Echocardiography	68.1	123.4	<0.001
	MRI	217.6	265.5	<0.001
	Nuclear Medicine	135.6	185.9	<0.001
	General Radiograph	114.0	125.9	<0.001
	Ultrasound	73.3	124.8	<0.001
Hospital_B	General Radiograph	113.8	73.8	<0.001
	Ultrasound	107.3	65.3	<0.001
Hospital_D	General Radiograph	152.0	72.0	0.03
	Ultrasound	103.8	44.5	<0.001
Hospital_G	General Radiograph	98.2	154.5	<0.001
Hospital_F	General Radiograph	243.5	178.7	0.03
Hospital_E	General Radiograph	244.8	181.0	0.02
Hospital_C	General Radiograph	223.0	133.8	0.03

Mastiff Health Authority

Administrative data for all unverified report turn-around-times (TAT) for outpatients was collected from the Radiology Information System (RIS) and the Management Information System (MIS) for each modality within scope in the Mastiff Health Authority for the period June 2004 to August 2005 (N = 177,855). As a result of staggered implementation dates for PACS at the 3 sites in the Mastiff Health Authority, the pre and post implementation period differ depending on the month of implementation: June, July or August 2004. A summary of total exams and data collection periods by modality and site for the Mastiff Health Authority is presented in Table 4-25.

Table 4-25
Exam Total by Modality and Site
Mastiff Health Authority

Site	Modality	Time Frame	Total Exams
Hospital_H	Cat Scan	June 2004 – June 2005	9,240
	Echocardiography	June 2004 – June 2005	1,547
	MRI	June 2004 – June 2005	4,629
	Nuclear Medicine	June 2004 – June 2005	13,009
	General Radiograph	June 2004 – June 2005	56,916
	Ultrasound	June 2004 – June 2005	12,581
		Total Exams	**97,922**
Hospital_I	Cat Scan	July 2004 – July 2005	9,215
	Echocardiography	July 2004 – July 2005	995
	Nuclear Medicine	July 2004 – July 2005	6,145
	General Radiograph	July 2004 – July 2005	47,266
	Ultrasound	July 2004 – July 2005	9,807
		Total Exams	**73,428**
Hospital_J	General Radiograph	Aug 2004 – Aug 2005	6,505
		Total Exams	**6,505**
		Total Exams Within Scope for all Sites	**177,855**

Table 4-26 presents the summary of the tests of significance for the monthly average turn-around-time (TAT) for sites in the Mastiff Health Authority by modality for pre and post PACS implementation. Detailed descriptions of TATs for the Mastiff Health Authority, by modality and site, are presented in Appendix "N".

Table 4-26
Average Monthly TAT by Modality and Site
Mastiff Health Authority

Site	Modality	Average Monthly TAT		p-value
		Pre PACS	Post PACS	
Hospital_H	Cat Scan	88.4	67.4	<0.001
	Echocardiography	175.4	135.0	<0.001
	MRI	165.5	149.4	0.020
	Nuclear Medicine	48.4	53.9	<0.001
	General Radiograph	85.8	57.4	<0.001
	Ultrasound	72.3	59.6	0.010
Hospital_I	Cat Scan	48.2	48.0	0.820
	Echocardiography	87.2	93.5	0.068
	Nuclear Medicine	54.2	43.7	<0.001
	General Radiograph	107.4	81.3	<0.001
	Ultrasound	57.4	55.5	0.110
Hospital_J	General Radiograph	138.1	114.2	<0.001

5. Reduced Patient Transfers

This indicator is a measure of the impact of PACS on the number of patient transfers between facilities due to the ability to share images and consult remotely. Administrative data for this indicator was not available from PACS hospitals in the Mastiff and Terrier Health Authorities. Hospital information systems in Newfoundland and Labrador record that a patient was transferred, but not why the transfer occurred.

6. Cost per Exam in Film versus in PACS: Terrier Health Authority

The cost per exam analysis was limited to the Terrier Health Authority as it was the only Health Authority in the province that had no PACS prior to the 2005 implementation. The analysis estimated costs associated with exams in the film environment and compared it to the costs associated with exams in the PACS environment. The analysis examined a five-year window as described below in Table 4-27.

Table 4-27
Summary of Transition from Film to PACS (Modalities in Scope)
Terrier Health Authority

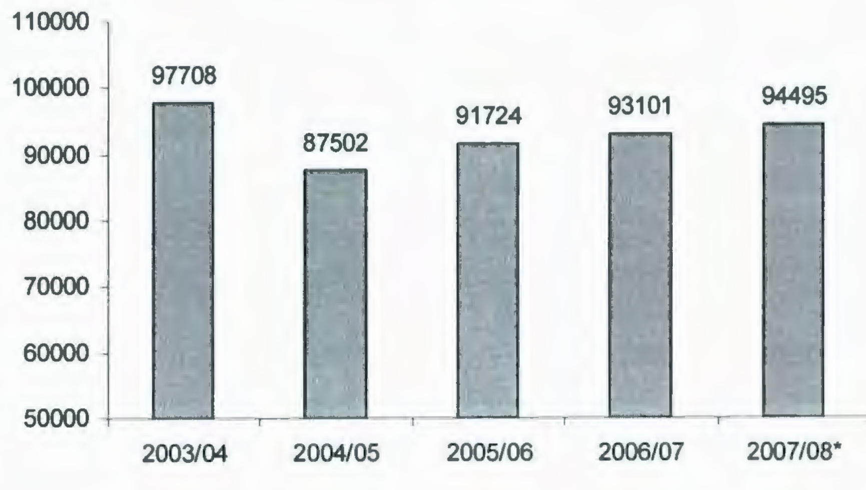
Year	Environment	Comment
2003/04	Film	No PACS
2004/05	Film	No PACS
2005/06	Film/PACS	PACS sites went live Dec 05 – Jun 06
2006/07	PACS	98% Filmless (Modalities in Scope)
2007/08	PACS	100% Filmless (Modalities in Scope)

Figure 3 presents the total number of exams produced for the Terrier Health Authority for years 2003/04 – 2007/08. Modalities in scope for the cost per case analysis included CAT Scan, echocardiography, MRI, nuclear medicine, general radiograph, and ultrasound. Note that in 2004/05 there was a change in reporting radiology exams under the Management Information System (MIS) Guidelines.

Prior to 2004/05 if a patient had one procedure (e.g., dye injection) and one positioning, but had two exams taken (e.g., hip and back), the number of exams reported was two (2), one each for the hip and back. In 2004/05 this was changed such that, using the above example, only one exam would be reported under the new MIS Guidelines.

Figure 3

Total Exams by Fiscal Year
Terrier Health Authority



* Estimated

The final costs for PACS hardware, software, human resources, and data storage in the Terrier Health Authority is provided in Table 4-28. Networking cost for PACS are excluded from the Table, given that the provincial network infrastructure is being developed by the province to support all EHR traffic, not only PACS. Further, all networking costs associated with the provincial HIN will be the responsibility of the Ministry of Health, not the regional authorities. It is recognized that costs for EHR network infrastructure across jurisdictions will be highly variable and will depend on many factors, including the number of sites involved, the amount of traffic on the network and the desired speed of data transfer (i.e., bandwidth). Although not included in the analysis, the Centre for Health Information estimated total networking costs for all EHR information systems for the province at $24,000 per month, or $288,000 annually, with PACS expected to require 50-75% of the total bandwidth. The annual networking costs for PACS in the Terrier Authority were estimated at $43,200. It is important to understand that these are high level estimates, as the HIN network has not yet been fully implemented in the province, and final costs may differ significantly from the estimates provided. Within this context, hardware costs in the Terrier Authority amounted to $2,398,790, software costs $932,270, human resources $400,900, and data storage $200,000. Total implementation costs were $3,931,960, with ongoing maintenance costs of $229,000.

Table 4-28
Total PACS Implementation Costs
Terrier Health Authority

PACS Hardware	Hardware	Actual
	Core PACS Hardware	$351,970
	DICOM Print Server & Integration Fees	$13,980
	Diagnostic, Clinical & QC Workstation - Hardware	$737,060
	DICOM Gateways	$176,280
	RIS/PACS Brokers	$76,800
	CR&DR	$1,042,700
	Total	**$2,398,790**
PACS Software	Software	Actual
	Core PACS Software	$298,040
	Workstation - Software & Integration Fees	$528,610
	Web Servers, Software Licenses & Integration Fees	$105,620
	Total	**$932,270**
HR	PACS Vendor	$400,900
Other	Data Storage	$200,000
	Total Costs	**$3,931,960**
Annual Maintenance Costs $229,000		

The $2.4 million in hardware costs have been financed using a 15% declining balance over six years (Table 4-29). The hardware is considered to have more value when first purchased, and as such a higher proportion of the overall hardware costs are allocated at the beginning of the period.

Table 4-29
PACS Hardware Depreciation Schedule
Terrier Health Authority

Year	Book Value-Beginning	Rate	Depreciation Expense	Book Value - Ending
1	$2,398,780	15%	$359,820	$2,038,970
2	$2,038,970	15%	$305,850	$1,733,120
3	$1,733,120	15%	$259,970	$1,473,150
4	$1,473,150	15%	$220,970	$1,252,180
5	$1,252,180	15%	$187,830	$1,064,350
6	$1,064,350	15%	$159,650	$904,700

For the purpose of this cost per case analysis, the hardware costs are considered an ongoing expense, given that once the hardware has been fully depreciated, the hospital will most likely need to replace and/or upgrade the equipment. Based on this assumption, the depreciation expense is included as a part of the cost per exam.

Costs in Film Environment

Operational costs in the film environment and the number of exams filmed for years 2003/04-2006/07 is presented in Table 4-30. Given changes in MIS reporting of radiology exams following 2003/04, the 2004/05 fiscal year was chosen as the base year for reporting the cost per exam in the film environment. Note that capital costs in the film environment are not factored in when estimating cost per exam. This is because the equipment (e.g., Computed Radiography) needed to produce the exam in film is basically the same equipment needed to produce the exam in PACS. This type of equipment was also excluded when estimating costs per exam in the PACS environment. Some capital costs are included in the PACS environment, given these costs are related to communications and storage, not exam generation (see Tables 3-30 and 3-31).

Table 4-30
Film Environment Costs
Terrier Health Authority

Indicators	2003/04	2004/05	2005/06	2006/07	2007/08*
Exams					
Total Exams	97,708	87,502	91,724	93,101	94,495
Total Film	97,708	87,502	72,254	1,606	0
% Film	100%	100%	79%	2%	0%
Film Costs					
Master and Insert Bags	$29,909	$31,737	$32,460	$18,577	0
Other Paper expenses	$0	$0	$0	$0	0
Film	$324,892	$376,950	$325,401	$23,378	0
Laser Film	$0	$0	$0	$0	0
Processing	$22,507	$16,348	$12,032	$2,184	0
Processor, Laser maintenance	$0	$0	$0	$0	0
Courier/Taxi	$13,613	$15,501	$20,456	$9,058	0
Off site storage	$0	$0	$0	$0	0
Total Supplies	$390,921	440,536	$390,349	53,197	0
Human Resources (HR)					
Film Librarians	$128,333	$128,333	$132,183	$87,524	$43,762
Dark Room Staff	$80,624	$80,624	$83,043	$21,383	0
Total HR Costs	208,957	208,957	$215,226	$108,907	$43,762
Total Film Costs	599,878	649,493	$605,575	$162,104	$43,762

* estimated

Operational Costs in PACS Environment

Operational costs in the PACS environment and the number of exams digitized for years 2003/04-2006/07 are presented in Table 4-31. Given there was still residual film in 2006/07, and because 2007/08 was the first full year for all PACS service contracts, the 2007/08 fiscal year was chosen as the base year for reporting the cost per exam in the PACS environment.

Table 4-31
PACS Environment Costs
Terrier Health Authority

Indicators	**2003/04**	**2004/05**	**2005/06**	**2006/07**	**2007/08***
Exams					
Total Exams	97,708	87,502	91,724	93,101	94,495
Total PACS (Digital)	0	0	19,470	91,495	0
% Digital	0%	0%	21%	98%	100%
PACS Costs					
PACS Consumables Costs					
CD production	$0	$0	$25	$100	$100
Consumables Costs Total	$0	$0	$25	$100	$100
Equipment and Service Costs					
Computed Radiography (Communication Upgrades)	$0	$0	$0	$61,215	$149,756
Site PACS Services	$0	$0	$0	$161,067	$298,623
Local Image Maintenance	$0	$0	$0	$0	$55,020
Network Service Contract	$0	$0	$0	$62,500	$62,500
Equipment/ Service Costs Total	$0	$0	$25	$284,782	$565,899
Human Resources (HR)					
PACS coordinator	$0	$0	$32,502	$65,004	$68,976
PACS support staff	$0	$0	$6,250	$0	$0
BioMed	$0	$0	$12,499	$6,250	$0
HR Total	$0	$0	$51,251	$71,254	$68,976
PACS Costs Total	**$0**	**$0**	**$51,276**	**$356,136**	**$634,975**

* estimated

Implementation Costs in PACS Environment

Table 4-32 presents the implementation costs (hardware and software depreciated) for PACS incurred in the Terrier Health Authority over the period 2004/05 – 2007/08. Total implementation costs over this four year period were $2,433,811.

Table 4-32
PACS Implementation Costs (Hardware/Software Depreciated)
Terrier Health Authority

Indicators	2003/04	2004/05	2005/06	2006/07	2007/08*
	Implementation Costs				
Number of Exams	97,708	87,502	91,724	93,101	94,495
Human Resources	$0	$175,000	$400,900	$0	$0
Software (straight line method over 3 years	$0	$0	$310,757	$310,757	$310,757
Hardware (15% Dep.)	$0	$0	$359,820	$305,850	$259,970
Total	$0	$175,000	$1,071,477	$616,607	$570,727

*estimate

Table 4-33 present the average cost per exam in the film environment compared to the PACS environment. The estimated cost per exam in the film environment is provided for both 2003/04 and 2004/05. As previously noted, 2004/05 was chosen as the baseline year for cost per exam in film, given that a change in MIS reporting for radiology exams came into effect this year. The comparative year for PACS would be 2007/08, as the majority of the PACS implementation was completed during 2006/07.

The operational cost (non-adjusted) per exam in the film environment was estimated at $7.4 (2004/05) compared to $7.2 in the PACS environment (2007/08). When the implementation costs for PACS were included, the cost per exam in the PACS environment in 2007/08 increased to $13.2. Adjusting costs per exams based on a 4% annual inflation rate results in the cost per exam in the film environment being estimated at $9.5 (2004/05) compared to $11.8 in the PACS environment (2007/08). With respect to choosing a 4% inflation rate, several factors were considered. Generally, we can expect wage inflation to approximate 3 to 3.5% per year, whereas drugs and medical/surgical supplies can experience inflation around 10% per year, and general inflation is about 2.0% per year. While it can be expected that most ROI models would use a 3-3½ % inflation rate (as wages are the predominant driver in expenses), a more robust rate of 4% was chosen for the PACS ROI in the Terrier Health Authority to minimize the risk of underestimating increasing PACS capital costs.

Table 4-33
Cost per Exam in Film Environment Compared to PACS
Terrier Health Authority

Indicator	Film 03/04	Film 04/05	Film/PACS 05/06	Film/PACS 06/07	PACS 07/08*
Film Environment (Operational)					
Exams	97,708	87,502	72,254	1,606	0
Expenses	$599,878	$649,493	$605,575	$162,104	$43,762
PACS Environment (Operational)					
Exams	0	0	19,470	91,495	94,495
Expense	$0	$0	$51,276	$356,136	$634,975
PACS Environment (Implementation)					
Software/ Hardware	$0	$175,000	$1,071,477	$616,202	$570,726
Total Exam Costs					
Total Cost	$599,878	$824,493	$1,728,328	$1,134,442	$1,249,463
Cost per Exam (Operational: Adjusted for Inflation)					
Total Exams	97,708	87,502	91,724	93,101	94,495
Operational Cost /Exam	$6.1	$7.4	$7.2	$5.6	$7.2
Adjusted for Inflation	$6.1	$7.4	$6.9	$5.1	$6.4
Cost per Exam (Operational + Implementation: Adjusted for Inflation)					
Implementation Costs/Exam	0	$2.0	$11.7	$6.6	$6.0
Total Costs/Exam	$6.1	$9.4	$18.8	$12.2	$13.2
Adjusted for Inflation	$6.1	$9.5	$18.3	$11.3	$11.8

* estimated

Table 4-34 presents the results of a second approach taken to compare the cost per exam in the film environment with that in PACS. This approach calculates the cost per exam in the PACS environment based on constant payments (one a year for 10 years) and a constant interest rate (6%). The average cost per exam in PACS is found by dividing the Net Present Value (NPV) of PACS by the total estimated exams generated over an 11 year period. NPV is the total amount that a series of future payments is worth today. The following notes are important in interpreting the results provided in the table:

1) Both costs and benefits have been brought back to year 0.

2) Total exams for years 2007/08 – 2015/16 are estimated to increase 1.5% per year

3) Total exams have been discounted at the same rate as the total cost for PACS so that the cost/exam calculation provides a valid estimate.

$$\text{Discount Amount} = \text{total amount} * (1 + 0.06)^{-n}$$

where n is the number of years into the project (i.e. 2005/06 = 0, 2006/07 = 1, 2007/08 = 2,…)

4) Increases for staff in both the film and PACS environment have been held constant

In using this constant payment/interest approach the average cost per exam is estimated at $8.50 per exam.

Cost per exam = NPV (Cost)/NPV (Exams)
= Hardware + Software + Total Discounted Cost/744,891
= $2,398,700+$932,270+$2,967,589/744,891
= $6,298,559/744,891
= $8.50

Table 4-34
Cost Per Exam in PACS: Constant payments and interest rate

Indicator	Fiscal Year				
	2005/06	2006/07	2007/08	2008/09	2009/10
	Project Year				
	0	1	2	3	4
Total Exams	91,724	93,101	94,495	95,012	97,351
Total PACS (Digital)	19,470	91,495	94,495	95,012	97,351
Discounted PACS	19,470	86,316	84,100	79,774	77,111
% Digital	21%	98%	100%	100%	100%
One time Upgrades		$284,782	$565,899	0	0
PACS Staff		$71,254	$68,976	$68,976	$68,976
Hardware	$2,398,700				
Software	$932,270				
Annual Maintenance		$229,000	$229,000	$229,000	$229,000
Total PACS Costs		$585,036	$863,875	$297,976	$297,976
Discounted Cost		$551,921	$768,846	$250,186	$236,025

Table 4-34 (Cont….)

Fiscal Year (Continued...)						Total
2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	
Project Year (Continued...)						
5	6	7	8	9	10	
98,811	100,271	101,731	103,191	104,651	106,111	1,086,449
98,811	100,271	101,731	103,191	104,651	106,111	1,012,589
73,837	70,687	67,657	64,743	61,943	59,252	744,890
100%	100%	100%	100%	100%	100%	
0	0	0	0	0	0	
$68,976	$68,976	$68,976	$68,976	$68,976	$68,976	
$229,000	$229,000	$229,000	$229,000	$229,000	$229,000	$2,290,000
$297,976	$297,976	$297,976	$297,976	$297,976	$297,976	$3,832,719
$222,665	$210,061	$198,171	$186,954	$176,372	$166,388	$2,967,589

4.4 Management Documents

Total Cost of Ownership

In 1998, five (5) years prior to establishing a partnership with Canada Health Infoway, the Newfoundland and Labrador Centre for Health Information (NLCHI) prepared a Benefits Driven Business Case (BDBC) at a cost of approximately $400,000. This document outlined the benefits (i.e., health, economic and financial) that could be expected if a Health Information Network (HIN) were implemented in the Province of Newfoundland and Labrador. As noted earlier, the BDBC recommended a phased implementation approach for the eight (8) components of the HIN, with each preceding phase supporting the implementation of the subsequent phase:

1. Unique Personal Identifier/Client Registry
2. Personal Medication Dispensing History (i.e., Component of Pharmacy Network)
3. Personal Diagnostic Service History (i.e. Diagnostic Imaging and Laboratory)
4. Diagnostic Service Requestor Decision Support (i.e., Laboratory)
5. Personal Medication Regimen (i.e., Component of Pharmacy Network)
6. Personal Health Information Profile (i.e., the EHR)
7. Physician Practice Pattern Profiling
8. Clinical Decision Support Tools

As part of the BDBC, a cost benefit analysis was carried out for the eight (8) HIN components. As previously noted, back in 1998, the province of Newfoundland and Labrador was running large budget deficits, and there was no interest by the government of the day to invest in large scale IT projects. To overcome this lack of interest by government, NLCHI focused primarily of the first two components of the HIN, namely the Unique Personal Identifier/Client Registry and the Personal Medication Dispensing History, as these phases had the most promise for achieving a return on investment (ROI) in the shortest period of time.

In 1998, a high level cost benefit analysis was carried out on what would eventually become the Province's PACS, i.e., the Personal Diagnostic Service History. This analysis found that if the Personal Diagnostic Service History was implemented in the same year as the Client Registry and the Personal Medication Dispensing History, it would cost $7,315,000 with ongoing maintenance costs of $659,000. The annual benefit was estimated at $2,407,000 resulting in a 5 year net present value (NPV) of (-) $2,104,000. NPV is a standard method for the financial appraisal of long-term projects. Used for capital budgeting, NPV measures the excess or shortfall of cash flows in present value terms, once financing charges are met. By definition, NPV = present value of net cash flows. Of note, given the 5- year NPV was negative, it is not surprising that PACS was not presented as a deliverable at the time initial discussions on the EHR were ongoing between NLCHI and the provincial government.

It is important to recognize that the vision of the Personal Diagnostic Service History as presented in the BDBC in 1998 was not the same vision that led to PACS being implemented in the province in 2005. In 1998, both digital imaging and laboratory results were included in the costs benefit analysis of the Personal Diagnostic Service History. In 2005, the province put in place a Health Information Network (HIN) plan that had PACS and the Laboratory Information System implemented as separate EHR projects, although they both will eventually connect to the HIN.

While the cost estimates presented in the 1998 business case were high level, the BDBC did produce the first estimate for the total cost of ownership, and the potential for a return on investment, for the diagnostic imaging component of an EHR for the province of Newfoundland and Labrador.

PACS Project Charter

In June 2005, the Centre for Health Information, in partnership with the Department of Health and Community Services (DHCS), the Regional Health Authorities and Canada Health Infoway, developed a PACS Project Charter that set out the vision for the implementation of PACS in the province of Newfoundland and Labrador. At a cost of $175,000, the Project Charter identified a number of key deliverables, which came to be known as the A^5 vision (Any Patient, Any Image, Any Report, Anywhere, Anytime):

1. To achieve filmlessness for data capture in defined PACS enabled sites by mid-2007 (*A*ny image, *A*ny report)

2. To achieve filmlessness for data capture in health authorities by mid-2006 (*A*ny image, *A*ny report).

3. To make exams and reports available to all radiologists and physicians 98% of the time, (*A*nywhere, *A*nytime).

4. To develop a provincial PACS archive that contains 98% of the new digital provincial DI exams and reports (*A*ny image, *A*ny report)

5. To develop a provincial PACS archive subject to applicable provincial and national privacy and confidentiality requirements (*A*nywhere)

4.4.1 Total Cost of PACS Ownership

It would be impractical to attempt a total cost of ownership for a provincial implementation that was fragmented across nine health boards, spanned 9 years, was project based, and funded from multiple sources through various programs. For this study, a total cost of ownership analysis was carried out only for the period 2005/07 (i.e., the Infoway/Provincial PACS partnership), and focused on two separate geographical areas, the province as a whole, and the Terrier Health Authority.

4.4.1.1 Total Cost of PACS Ownership: Province 2005/07

As part of the PACS Project Charter, a detailed financial management plan was developed that estimated costs to the province in setting up the Project Management Office, as well as vendor implementation and equipment costs. All costs identified were broken out into what the province would contribute and what would be contributed by Infoway. The estimated costs in establishing the Provincial Project Management Office are presented in Table 4-35. Total costs for project management were estimated at $3,114,184, of which the province would contribute $1,172,284 (38%) and Infoway $1,941,900 (62%).

Table 4-35
Estimated Costs PACS Project Management Office (2005/07)
Newfoundland and Labrador

Cost Centre	Project Cost	Infoway Cost	NL Cost
Project Management	$661,564	$496,173	$165,391
Project Implementation	$743,703	$557,778	$185,926
Migration support	$116,686	$87,514	$29,171
CR Integration	$201,339	$201,339	$0
Benefits Evaluation	$266,445	$266,445	$0
Knowledge Management	$109,767	$109,767	$0
Privacy Impact Assessment	$79,258	$59,444	$19,815
HIN Upgrades	$41,365	$0	$41,365
Sub-Total	**$2,220,127**	**$1,778,459**	**$441,668**
Net Effective Tax (9.19%)	**$204,030**	**$163,440**	**$40,589**
Contingency	$223,206	$0	$223,206
Sub-Total	**$2,647,363**	**$1,941,900**	**$705,463**
RIS Implementation	$466,821	$0	$466,821
Total	**$3,114,184**	**$1,941,900**	**$1,172,284**

Source: NL PACS Phase II Project Charter June 24, 2005 (Ministry of Health)

The total estimated vendor implementation and equipment costs are presented in Table 4-36. Total vendor and equipment costs were estimated at $19,723,527, of which the province would contribute $11,093,972 (56%) and Infoway $8,629,555 (44%).

Table 4-36
Estimated Costs for Implementation and Equipment (2005/07)
Newfoundland and Labrador

Cost Centre	Estimated Cost	Infoway Cost	NL Cost
PACS Servers	$2,059,324	$1,544,493	$514,831
Image Distribution	$773,242	$558,968	$214,273
Storage	$2,779,094	$2,084,321	$694,774
Workstation/Viewing Stations	$2,361,237	$1,535,107	$826,130
Modalities	$4,981,236	$565,370	$4,415,866
Information Systems	$698,783	$574,087	$124,696
Test Environment	$69,876	$52,407	$17,469
Vendor Professional Services	$1,317,992	$988,494	$329,498
Sub-Total	$15,040,783	$7,903,247	$7,137,536
Meditech Modifications	$500,000	$0	$500,000
Other Hardware	$2,522,709	$0	$2,522,709
Sub-Total	**$3,022,709**	**$0**	**$3,022,709**
Effective Tax (9.19%)	**$1,660,035**	**$726,308**	**$933,727**
Total	**$19,723,527**	**$8,629,555**	**$11,093,972**

Source: NL PACS Phase II Project Charter June 24, 2005 (Ministry of Health)

The total estimated costs for implementing PACS in Newfoundland and Labrador over the period 2005/07 are summarized in Table 4-37. Total costs were estimated at $22,837,711, of which the province contributed $12,266,256 (54%) and Infoway $10,571,455 (46%). Note: networking costs are not included in this summary, but have been estimated at $288,000 per year (see p. 158-159).

Table 4-37
Total Estimated PACS Implementation Costs (2005/07)
Newfoundland and Labrador

Cost Centre	Project Cost	Infoway Cost	NL Cost
Project Management Office	$3,114,184	$1,941,900	$1,172,284
Total Implementation Costs	$19,723,527	$8,629,555	$11,093,972
Total	**$22,837,711**	**$10,571,455**	**$12,266,256**

Source: NL PACS Phase II Project Charter June 24, 2005 (Ministry of Health)

4.4.1.2 Total Cost of PACS Ownership: Terrier Health Authority 2005/07

Unlike the challenges in calculating the total cost of PACS ownership at the provincial level, it was possible for the Terrier Health Authority, given it was the only health authority in the province that did not have any PACS prior to the implementation that occurred in 2005. As presented in Table 4-38, total professional fees budgeted for the Terrier Health Authority was $450,900, with actual costs coming in at $400,900. The positive variance between budgeted versus actual cost was the result of having lower costs for migration services, which was offset somewhat by not budgeting for the Project Manager and

Business Analyst. As noted in the table, some professional fees were budgeted as provincial resources within the Centre for Health Information.

Table 4-38
Professional Costs (2005/07)
Terrier Health Authority

Category	Description	Details	Costs	
			Budgeted	Actual
Human Resources	Primary Professional Services	Project Manager	$0	$20,000
		Business Analyst	$0	$50,000
	Vendor Consultants	GE Professional Services	$60,000	$60,000
		GE Training	$73,600	$73,600
		PACS Installation and Integration Services	$122,100	$122,100
		Data Migration Services	$195,200	$75,200
	NLCHI[1]	Project Lead	n/a	n/a
		Business Lead	n/a	n/a
		Technical Lead	n/a	n/a
		Regional Implementation Teams	n/a	n/a
		Total	**$450,900**	**$400,900**

[1]NLCHI provided these professional resources (see Table 4-35)

Table 4-39 presents the costs for hardware, software, storage and ongoing maintenance for PACS in the Terrier Health Authority. Total costs in the technical environment were budgeted at $3,628,450, with actual costs coming in at $3,531,060. The positive variance was the result of lower hardware costs offset somewhat by higher software costs.

Table 4-39
Technical Environment (2005/07)
Terrier Health Authority

Category	Description	Details	Costs	
			Budgeted	Actual
Technical Environment	Hardware	Core PACS Hardware	$351,970	$351,970
		DICOM Print Server and Integration Fees	$13,980	$13,980
		Diagnostic, Clinical and QC Workstation - Hardware	$855,170	$737,060
		DICOM Gateways	$176,280	$176,280
		RIS/PACS Brokers	$76,800	$76,800
		CR and DR	$1,121,970	$1,042,700
		Total Hardware	$2,596,170	$2,398,790
	Software	Core PACS Software	$298,040	$298,040
		Diagnostic, Clinical and QC PACS Workstation - Software and Integration Fees	$428,620	$528,610
		Web Servers, Software Licenses & Integration Fees	$105,620	$105,620
		Total Software	$832,280	$932,270
	Other	Data Storage Space	$200,000	$200,000
		Total	$3,628,450	$3,531,060
Ongoing Maintenance $229,000				

Table 4-40 presents a summary of the total cost of ownership of PACS for the Terrier Health Authority. Total costs to implement PACS in Terrier were budgeted at $4,079,350, whereas actual costs were $3,931,960. Ongoing maintenance is budgeted at $229,000 annually. Note: annual networking fees for the Terrier Authority were estimated at $43, 200. However these costs are not included in this costing analysis (see p. 154-155).

Table 4-40
Summary of Total Cost of Ownership (2005/07)
Terrier Health Authority

Cost Centre	Budgeted Costs	Actual Costs	Variance
Professional Fees	$450,900	$400,900	(+) 50,000
Technical Environment	$3,628,450	$3,531,060	(+) 97,390
Total	**$4,079,350**	**$3,931,960**	**(+) $147,390**
			Ongoing Maintenance $229,000

4.5 Key Informant Interviews

Initial contact with key informants to request an interview was either through e-mail or telephone call (i.e., physicians), with a follow-up telephone call approximately one week later; a total of 20 key informants subsequently agreed to be interviewed. Across the three (3) health authorities, nine (9) key informants interviewed were from Mastiff, one (1) from Spaniel, and eight (8) were from Terrier. The Health Information Network (HIN) Director at NLCHI and the Provincial PACS Project Manager had provincial responsibility for PACS implementation. The majority of key stakeholders interviewed had between 1 – 5 years post PACS experience in the province, depending on the health authority in which he/she worked in. For convenience, 18 interviews were completed over the telephone, while 2 were carried out face-to-face. Interviews required between 30-40 minutes to complete and took place between May – July, 2007. Table 4-41 presents a summary of key informants interviewed.

Table 4-41
Summary of Key Informants Contacted/Interviewed

Personnel	Contacted	Interviewed
PACS End Users		
Radiologist	48	5
Radiology Technologist	45	2
PACS Administrator	3	1
Physician		
GP	58	0
Specialist	42	7
Total	100	7
PACS Management	11	5
Total	206	20

Results from the key informant interviews are presented by the following themes related to PACS: 1) perceived benefits, 2) unintended consequences, 3) gaps in the implementation process, 4) training, 5) lessons learned, 6) change management, and 7) overall perceptions.

4.5.1 Perceived Benefits

There were three distinct categories identified under the theme "perceived benefits" of PACS: a) availability of exams, b) increased productivity, and c) reduced report turn-around-time.

a) Availability of Exams: Benefits arising from increased efficiencies in making exams available for patient care in the PACS environment were further identified under four sub categories: i) access to primary exams, ii) access to historical exams/reports, iii) patient transfers/consultations, and iv) reduced duplicate exams.

i) Access to Primary Exams: Accessing primary exams by radiologists and physicians was considered more efficient in the PACS environment, given the need to travel to the film library in search of exams and/or reports had been all but eliminated. The elimination of lost film, the speed with which a image could be accessed via computer, and the reduction in the tensions within the radiology department when physicians were looking for film were also noted as benefits of PACS.

I think when PACS first came in, we found it a lot easier to see the x-rays, the x-rays were clearer, and easier to get, you weren't going around looking for films, you didn't have to go to the film library to pick up x-rays, that kind of stuff. So it was definitely easier. (Physician #6)

I mean, we have done away with all of our hard copy film and we no longer have to search through film bags and massive storage of old films. We now have them in the archives here and we can access them at any time. (Radiologist #5)

Just being able to view the images much more quickly on computer versus looking at a piece of film. You can scan through images much faster. (Radiologist #2)

The other thing is if someone had an x-ray yesterday at St. Clare's and it was a film based x-ray and now they're at the Health Science, well, in the old days I would have repeated it because it's over in St. Clare's and I *can't physically get the film, or I can by taxi and that's a pain in the ass, whereas now I can look on the computer and it's there. That's really helpful. (Physician #7)*

Well, certainly the issue of the film library, it was immediately apparent that that was no longer a huge -- I mean, that used to be a source of contention such that we'd have notices coming out saying do not appear before 11 o'clock, angry radiologists shouting at residents and interns who were trying to get access to films at some point when it was important, but it didn't seem to be appropriate to the diagnostic imaging program and so on. So all that tension immediately went away. (Physician #4)

<u>ii) Access to Historical Exams/Exam Comparisons:</u> In support of patient diagnosis and disease progression, radiologists and physicians require access to a patient's historical exams for comparison to more recent exams. Getting access to historical exams/reports in the film environment sometimes took considerable time, with the time required being somewhat dependent on how long ago the exam was taken. In some cases, the historical exams/reports were never found. With PACS, all exams/reports are available for comparison either on the short term (current) or long term (historical) archive, and in most cases can be accessed within seconds.

The ability to immediately call up that patient's plain film, or CT or ultrasound and look at those images and compare it to my own. I think that's been a real big improvement. I think that's the strongest power I've seen from PACS. (Nuclear Medicine Specialist)

...the biggest improvement I've seen for PACS, the sort of instantaneous or very rapid ability to compare examinations with other diagnostic imaging procedures. (Radiologist #3)

The biggest thing would be comparisons. Beyond the quick turn over of your day-to-day work, whenever you're comparing something, you know. Like, if *you have to compare a chest to an old chest. In the old days, we'll call it, I guess, you had to put in a request to the film library and what would take anywhere from five minutes to days to track it down, a day or two to track things down, you know, depending on how hard or how far back it had to go, and now -- I mean, we get set up now and it's 90 seconds. (Radiologist #4)*

...we do that a lot, especially if you're looking at chest x-rays and you see an abnormality there and the first question is was that there last year, and you can not only go back and get the prior films which is excellent because you can put them up next to each other without having to call radiology and have somebody go down and search through the files and take you half an hour. (Physician #5)

You can also compare old film, which is good, and you don't need to go to an x-ray bag or you don't need to send over to Radiology to get the patient's master bag because all the x-rays they have had are on PACS as well for you to compare. So it's easier that way too. (Physician #6)

...what I really love it for is I can look at old films and compare them whereas before you had to get out the x-rays and maybe you couldn't find them, or you had to wait for Radiology to bring them over to you, which took forever, but with this I can just click and find what the last x-ray looked like and compare it. That's a huge bonus because, oh, yeah, it looked exactly the same last time. (Physician #7)

The biggest thing for us is where I work in MRI and at the time there was only two scanners on the island, so a lot of patients come from out of town, and now with PACS we can easily bring up all their other films and all that type of stuff. (Technologist #1)

Some of the stuff we don't realize that's happening in the background, it's not involving radiology at all, but people who do still look at images. The areas particularly this happens in is Oncology where the Oncologists are looking at follow up examinations which are done outside the city, and they're comparing them with ones that were in city and they're doing, in essence, a tele-oncology practice where they have the imaging on the patients out there and they can supervise care on-line or via the telephone with all this backup. (Radiologist #1)

I mean, we have done away with all of our hard copy film and we no longer have to search through film bags and provide massive storage of old films. We now have them in the archives here and we can access them at any time, and we can call even old films forward. So it's been a remarkable *improvement in terms of comparing present examinations to old ones. (Radiologist #5)*

<u>iii) Patient Transfers/Consultations:</u> Transfer of patients between hospitals occurs when a patient requires specialized care that is not available at the originating site. In the film environment it was accepted practice to send the patient and their film to a second site for diagnosis and/or treatment. It was not uncommon for the film not to arrive with the patient, or if it arrived, it was not useful for patient care. PACS not only eliminated the need for the film to accompany the patient, but it also allowed the physician at the receiving site to review the exam prior to the arrival of the patient.

Before we would perhaps be waiting for everything before the images were sent, or the images would be sent without the patient, or the patient without the images, and it took a lot longer to organize things. (Radiologist #1)

...before we had provincial-wide PACS or even the ability to transfers images efficient via PACS, things were repeated in patient transfers, like, if they were getting sent to St. John's from a centre outside St. John's, often there would be re-imaging because they didn't have pictures acceptable, so it would often be quicker than trying to get films or get whatever sent out and they would just re-image it. (Radiologist #4)

Great expectations for the smaller sites, even from Western to Eastern to be able to have that link from Western Memorial to the St. John's Health Care Corp, and then for the smaller sites in the Western region to be able to have images on their patients immediately here at Western Memorial because it benefits the patient so much, better than in the film world. You would have to wait for films and patients to be delivered. It's really fantastic. (PACS Administrator)

... one of the advantages of having it in a digital format is that if in the process of arranging for transfer, a clinician wants to have a discussion with a colleague at another site, then it's possible for two people in separate places to have the same information in front of them, and I suspect that actually makes a difference to the person who may be receiving the patient if they can look at that information up front. So I would say it's enhanced at least the transfer process. (Physician #2)

....if they have a trauma in Clarenville that always end up in St. John's, then usually what I'll do even though the patient isn't coming directly for my care, they're coming to one of the surgeons, is when I know they're coming, the nurse from that site will call in and say, look, we've got this patient coming in for (surgeon) and here's his name, I'll go right to the PACS and if I can't get the films right away myself, we just call the Radiology Department of the referring hospital and say send them in to us. Usually I can see the films even before the patient arrives. (Physician #5)

It helps actually make it efficient for people to have access to specialists in terms of radiologists, plus they can see the images. If they're going to refer to another specialist in St. John's or wherever, the Cancer Clinic or whatever, images can be transferred in, decisions can be made before the person ever shows up, you know. (Radiologist #4)

In the film environment a patient and their film(s) would need to be transferred to a site having specialized services. Such transfers are not only stressful, disruptive and cause economic burden to the patient, but they are also resource intensive to the health system. PACS provides significant benefits, because the exam can be digitized and sent off site for consultation, thus reducing the number of unnecessary patient transfers.

I guess in terms of patient care rural area when referring physicians want to have an immediate consultation regarding the actual images rather than having them physically transported which would take a day or more, it can be done instantaneously, so no doubt the care of the patient was definitely improved by being able to consult radiologists immediately. (Radiologist #2)

In some instances, we would want to look at the results of CT scanning that had been done in Burin and it was possible through PACS to have those images read here in St. John's without the patient traveling would have a distinct advantage to that type of thing. (Physician #4)

I know for a fact with MRI, patients are done here and their surgeons are in St. John's and their images are available right away. So they haven't got to make the trip across the island to see the doctor, the doctor can view the images before they even see the patient. (Technologist #1)

...because we are site removed from here, we don't have a radiologist on staff, we probably utilize it more than other sites because now rather than transport patients, we can just make a phone call and say can you look at that for me. We utilize it a lot in that way... When you're dealing with injuries, say, is that really broken, should I send them or can they stay here, that kind of thing. It saves dragging patients around. (Technologist #2)

... now when we have emergencies here, in house emergencies, a patient falls or whatever, most often they would end up being transported to another hospital with their x-rays so that someone could look at them, and now I do them on PACS and call up the radiologist and say could you look at that and they'll look at it and say, yes, that's a fracture, send them out right away, or no, that patient is fine, tell them to keep an eye on him kind of thing. So it do, it really do -- when you're site removed from a radiologist like that, it really helps us. (Technologist #2)

A lot of times people had to go to St. John's to have their images done to see the specialist. If they lived up here, for instance, now they only have to go down the road to have it done and it's sent directly to their specialist and that's all they have to do. (Technologist #1)

Like, if a patient had a trauma series done out in Port Aux Basques, our radiologists could view it instantaneously, and not only that, a surgeon or a specialist in here at Western could look at the images and decide whether or not that patient would be transferred in. (PACS Administrator)

Oh, yes, that's one of the big things because they can refer to the specialist or the doctor at the bigger sites before there's even a transfer even talked about, and then if it's needed, the patient is transferred, whereas before in the film world you had to send the patient and we automatically send the films with the patient at that particular time. (PACS Administrator)

Once in a while, like, one of the doctors will come to me and say PACS was great the weekend, I didn't have to transfer a patient out to St. John's, I just sent the images or whatever. (DI Director)

Well, obviously, I mean, from the client side, I mean, just the ability to have images anywhere they need to be at any time. I mean, we've heard anecdotally from some specialists, you know, who have had consults with peers in St. John's or elsewhere that have had impacts on the need for patients to travel, have had quicker turn around time with respect to decisions for treatment. (IT Director)

Other benefits of PACS with respect to patient transfers/consultations included reducing wait lists, overcoming adverse weather and addressing temporary staffing shortages:

We have people who call us regularly throughout the province asking for consults of various things. If we have a long waiting list or something here, conditions then it can be done somewhere else and we can look at the images on a consult basis. (Radiologist #1)

The other group is again a group that you don't really consider, the neonatologists, so you have babies that are born and are in trouble, particularly in the middle of the winter, so they may be stranded for a couple of days because of weather. So the (neonatologists) are monitoring the chest x-rays as if they were in their own department and giving advice on the phone with all the other parameters that they are given information on.(Radiologist #1)

The fact now that for a general x-ray that we do in Burgeo or Port Saunders, it can be sitting on the radiologist's desk within seconds, viewed on a radiologist's workstation. It's no longer a factor of having to get it physically transported here and everything that goes along with that, and in the winter the problems with respect to transportation and weather and this kind of thing. I mean, it's taken that away. (IT Director)

When the radiologist in Gander who reported most of the Nuclear Medicine studies was ill for a protracted period of time, I actually reported virtually all the Nuclear Medicine done in Gander. They were able to send directly to my workstation. So absolutely it was a great help there. (Nuclear Medicine Specialist)

(iv) Reduced Duplicate Exams: A second exam may need to be taken if the original is lost, stolen, or simply not available at the time it is needed for patient care. When a duplicate exam is taken it uses up resources, delays treatment and exposes the patient to unnecessary radiation. With PACS, the patient's exams are rarely lost, and are available almost instantaneously 24/7. PACS eliminates the need for manually searching, and can be viewed by multiple people at the same time in different locations.

That wasn't a very common finding as I was concerned, but it certainly occurred enough to create a nuisance and to create unnecessary radiation exposure to patients, you know. (Radiologist #5)

The problems with films going missing and all that kind of stuff, it's not an issue any more. (Physician #1)

It was pretty common, especially in the in-patient arena, to look for films and films couldn't be found, and certainly in an in-patient or more acute setting where treatment decisions are perhaps more urgent at times if the films weren't available, and it was pretty common in that kind of setting to repeat it, but a digital image is going to be available whether it's reported or not. (Physician #1)

Like, if they were getting sent to St. John's from a centre outside St. John's, often there would be re-imaging because they didn't have pictures acceptable, so it would be often quicker than trying to get film or get whatever sent out and they would just re-image it. (Radiologist #4)

When a patient is sent in now because of a tertiary care problem, I mean, we have full access to most of the work that has been done at the regional hospitals. So that's been a huge asset, yes, because we haven't had to repeat everything again, and it's made it much more simplified. (Radiologist #5)

I would imagine that whatever redundancy occurred because of losing films must have been addressed, although again I haven't seen any numbers on that. (Physician #4)

Films get lost, misplaced, put in different people bags for unknown reasons, and with PACS, it's all on archive. We just type up their name and it comes right up. (Technologist #1)

When I was in x-ray there was a lot of stuff had to be done over and over again. For instance, the developer might have eaten your film or something, so then you had to go and take the film over again, whereas in PACS there's none of that problem. (Technologist #1)

There isn't any of that any more, you know, you send the whole package of x-rays to a clinic and they get stuck in a corner somewhere and they can't find them, and when the patient shows up, they're lost. That doesn't happen any more. (Technologist #2)

We certainly have a reduced number of lost film being reported. (DI Director)

b) <u>Increased Productivity</u>: PACS removes many time consuming steps from the time a patient presents at registration to the time the report is made available to the referring physician. It would be expected that the productivity of radiologists, technologists, and physicians would improve with PACS. However, for smaller hospitals running efficient film environments, implementing PACS may only decrease waiting times, with patient throughput remaining relatively unchanged.

I would say efficiency of clinical service has improved. I think the efficiency with which you can be productive, I don't know if we're more productive because it's probably the same units of clinical care going on, but the efficiency with which you can do it, care has improved. (Physician #2)

Not being a radiologist, I don't know how it's impacted their day-to-day operations, but it seems to be a lot quicker because basically from our point of view you didn't have to wait around to get your hands on the film, right. You could still view the films while the patients were still over in the department. I would guess that, yes, productivity improved. (Physician #5)

Yes, my productivity has. It speeds everything up a little bit. The readers are very accommodating when it comes to exposures and stuff. I just love it.... the mixing of chemicals and cleaning of processors, all that part of it is taken out, and it's just wonderful. The filing part process is so much easier, so much time saving, it's wonderful. (Technologist #2)

I think productivity has improved because the radiologists don't need to be handling films, they don't need to be looking for films or taking them in and out of the bag, putting them up on the viewer in order to dictate them. With the technologists, it's basically the same type of thing, they don't need to wait for a film to be processed. (PACS Administrator)

It makes our workflow a quicker, you know. You don't have to go changing films out, you don't have to go looking for previous films. It makes a huge difference. (Radiologist #4)

Well, I mean, the time that's saved, I guess, I would have imagined that that would improve, but it is amazing how much time it saves because it avoids you having to go to the Radiology Department and track down the person who would pull the film, and then waiting for them to pull the film and you'd usually be in a line up, and then getting the films, and then you might have to go back because you needed to look at an old x-ray. So it would take sometimes hours to have a look at x-rays and discuss it with the radiologist, whereas now you get it within seconds basically. I mean, it's amazing how much time it saves. (Physician #1)

I mean, it literally takes seconds to get your images in front of your eyes. That's a huge thing, obviously. The way that increases your productivity during the day you can't really calculate I wouldn't think. I'm sure you could do an exam by exam and see how long would it take to take film down and put film up, but like I said, there's a 20 to 25 percent increase in through put for the average radiologist by doing it that way. (Radiologist #4)

So what you're doing is you're doing 50 patients in five hours versus 50 patients in seven and a half hours. I mean the productivity or through put, right, the through put is -- you know, the speed of through put has definitely increased. I mean, you can see down in Eastern it's phenomenal now when you go for an x-ray. There's no waiting. (Provincial PACS Project Manager)

c) Reduced Report Turn-Around-Time (TAT): While PACS has improved the time required to prepare the exam and make it available for reviewing by the radiologist, there is no clear evidence that this has translated into improved turn-around-times for the report. One of the factors involved in the failure to achieve this expected benefit appears to be a lack of transcriptionists.

We are, as you know, having a major problem at the moment with transcriptionists, so this is hindering our ability to turn around time to eventual signed report, but from a reporting point of view from what we have control over, it has certainly improved the time because what happens is there are little reminders built into the system so when I sign on every morning, certain examinations have been put into my box that I'm responsible for. (Radiologist #1)

Now because we have -- we ended up with 10,000 reports waiting for transcription here a couple of months ago, and we've had to put a blitz in trying to get extra people on and do overtime, and we still have a major amount left. We're down to around 2,000 now, but at any one time there are 2,000 examinations waiting for dictation at the moment. (Radiologist #1)

Yeah, well, as you know, there's other problems in that chain, right. I mean, there's a number of steps in getting a report out through the door, and there are problems, as you might imagine, at every single little step. The problem that we're having problems with the last six months, of course, is largely transcription. (Radiologist #3)

They should have, but in actual fact, there has been a major problem in dictating because of the stenographic problems they have been having, and I am sure you are quite aware of those, and if you're not, others will also advise you of that. (Radiologist #5)

Well, the answer to that would be no, to my knowledge here at Western, because we still have the same number of resources. We haven't increased our number of radiologists and, of course, the workload is faster getting through, so unless we have an increase in people to report, the turn around, to my knowledge, hasn't changed. I don't think it really got to do with the implementation of PACS. It got to do with the staffing here at Western. (PACS Administrator)

Yes, that's one aspect of it, but then it could sit in a draft status for several days before radiologists sign it....There's so many steps along the way and lots of times there's a delay in dictation too, if the truth be known. (DI Director)

I don't think the reports are necessarily any faster, and I don't know what the statistics are on that, but for ordinary film things such as maybe bone films or chest x-rays, or CT tests, many of us if we're used to looking at those kinds of films ourselves will make at least a preliminary assessment. (Physician #2)

I think they get them reported quicker. The dictation might get on the system a little bit quicker, but as for getting the signed report out, I don't know that that's improved much. (DI Manager)

The perception that report turn-around-times had not improved is not held by all professions. This was the case in the emergency room, in particular after hours and on weekends, where it is common practice for emergency room physicians to make a preliminary diagnosis from the exam, and follow up with the radiologist the following day only for the more complicated cases.

As a physician, even though we rely on the radiologist report, we can look at the films right away and often in the evening when you're seeing patients in Emergency or on the weekends, you can look at it yourself and consult the other physicians around you to help out and look at things. (Physician #1)

I'd say, yeah, because you're no longer waiting for bags of films to be shuttled back and forth. I'd absolutely say the turn around time has improved, yeah. (Radiologist #3)

Again being a site without a radiologist, our x-rays would have to wait until a radiologist visited us and that would be twice a week someone would come to this site and read all our x-rays, and now pretty much they're dictated the next day (Technologist #2)

4.5.2 Unintended Consequences

Key stakeholders were asked if there were any unintended consequences, either positive or negative, as a result of the PACS implementation. While this inquiry produced a diverse set of responses, the most frequent consequence noted was the reduction in physician/radiologist interaction within a site.

I guess the thing that maybe radiologists are finding that people are coming down less frequently to see them, and sometimes having that extra input because the clinical history provided on the requisition may not actually be the appropriate or detailed enough to actually help with the actual film review process. (Radiologist #2)

... a lot of times we'd get the referring doctor to come down and look at the pictures and discuss the report with us and so on, and we'd get feedback as well, we'd get important feedback from our clinical colleague saying you did a great job there, or you really missed this one, or whatever, and with the implementation of PACS and the distribution of imaging points in the hospital system, we get very little of that any more. (Nuclear Medicine Specialist)

Before PACS, many staff physicians would come down and we'd have consultations over films and so on. That doesn't happen any more now. (Radiologist #5)

The only negative thing I can see is that from a physician's point of view there's less consultation with the radiologist because before you would be forced to go to the Radiology Department, you would actually go to the radiologist office and discuss the patient and discuss the films, whereas now everything is so quick and the reports are coming back so quick, there's not as much interaction. (Physician #1)

Another consequence noted was the frustration with providing diagnostic services in a PACS environment when the system goes down because of scheduled or non-scheduled maintenance.

The only kind of bad thing, and this is predictable, sometimes with the downtime that we get, it's a real inconvenience. It doesn't go down very often, but when it does, what the technologists tell us we have to do is go over to their site so they can literally go over to their computer screen and view the images. (Physician #5)

I guess, you know, occasionally if a PACS system is down or if it's not working in the ER, then it can be a little frustrating, but I've got to say I haven't run into that problem very often. When we bring in computer programs, we never really count on them breaking down at times, but when they do, you really feel like you're lost, right, you can't do anything without it then. (Physician #6)

Well, the only thing that I really never gave much thought to was when the networking goes down, everything is at a standstill. (PACS Administrator).

Once or twice it just crashed, but most times they scheduled for maintenance, but, you know, when they schedule their maintenance, it's the most stupid times, right. They don't schedule maintenance at two in the morning, they schedule maintenance for Friday at five. Like, are you out of your mind? (Physician #7)

Most of the down time has been hardware specific, and it's been hardware that's been outside of PACS system itself. It's been mostly firewalls or data links, those type of failures at this point in time. (HIN Director)

We got support from (Vendor) and support from our IT Department, and all that's being monitored, and even with this provincial, when we went with provincial PACS, like, at the beginning everything is a bit slower, but everything is being worked on and being looked into further so that the down time will not be any longer than it absolutely necessarily has to. (PACS Administrator)

Other unintended consequences of PACS identified included the issue of recruitment, the impact on the practice of medicine, and the potential for carrying out audits, teaching and research.

It was always difficult to recruit to rural Newfoundland, anyway. Perhaps this will take some of the pressure off having an on site individual who may not be as experienced as other people, but on the other hand, you know, it's -- I'm trying to see how best to phrase this. That will be the only downside is that perhaps the pressure isn't on the local communities to get on site individuals any more if they require one, you know. (Radiologist #1)

...that is putting an inordinate amount of pressure on those people who have to report CAT scans, Ultrasounds, and other highly sophisticated imaging at a distance, and a lot of the physicians who are in our, shall we say suburban centres, small hospitals around the province, are just doing a CAT scan and if it doesn't show anything, they send the patient home, and if it does, they just send the patient

into the city. You know, it's taken away a lot of the practise of medicine, which is not a good thing because it's going to leave physicians in those rural communities totally dependent upon what the diagnostic images say rather than a thorough and complete examination of the patient. (Radiologist #5)

Imagine if there is some question about the competency of a physician and two or three other radiologists can just go into the system, take 20 or 30 cases at random and do an audit. (Radiologist #5)

What would be really nice, and I assume we've got the technology, is if there was a way on PACS to have a file, a teaching file, so that once we see an image, we could just kind of click and drag it into a folder for images. (Physician #1)

I'm sure there's other benefits of it, like, as far as using the images and that more for teaching and that kind of stuff, but I think from a clinical point of view, it is, yes. (Physician #4)

I'm sure that the research people are going to be utilizing it all the time, and the epidemiologists, but I'm not sure that the information is in there that they can get out, you know, without going through a whole lot of trouble. (Radiologist #2)

4.5.3 Gaps in the Implementation Process

Key informants were asked if there were any gaps or limitations that were evident throughout the PACS implementation. There were some issues identified with respect to the inexperience of the PACS Project Team in implementing a large scale PACS project. And while the PACS implementation experienced several delays, in November 2007 it became one of the first provincial PACS in Canada.

We had a small team to work with. The budget didn't allow for us to add on for these scope changes. (The vendor) came to the table with a very small project team that was very clear they were good at the small stuff, but some of them didn't have the big picture concept. (HIN Director)

One of the things that I would say is I would certainly test the architecture, the proposed architecture, and I would challenge the vendor a lot more than (the vendor) was challenged. (IT Director)

Limitations specific to hardware and software were also noted in the early months following PACS going live.

Sometimes in doing cases you had to actually get up from your desk and go to what they call that workstation to actually look at the images in the format that you would want to view them to make a diagnosis, but that's now gone because we now all have a software package on our workstation where we can do that. (Radiologist #2)

Sometimes when you're trying to recover a study that's been archived, it can take a significant amount of time to recover some of the old studies, and I understand -- I've been told at least that is reflected by the amount of media storage device that we have available. That, I guess, is one very small limitation. (Radiologist #3)

Limitations or gaps for us right now from a regional perspective, they're not a limitation of PACS itself; it's a limitation of our data communications provider where we have -- you know, I'll pick on Burgeo and Port Saunders as being the two most geographically remote from our corporate headquarters here in Corner Brook with respect to bandwidth, and the most we can buy for these sites right now is T1, and that's very expensive as well compared to what we would pay for some ATM based communications that just aren't available in those rural communities. So that's the gap for us now is really bandwidth. It's functional, you know, PACS is functional in those areas, but it could be better. (IT Director)

I would say like probably a year ago I wasn't really happy with it, but that had to do with my own computer system, but right now it's working great. (Physician #1)

There's always issues with quality of equipment, right. That's probably our biggest issue. (Physician #3)

They were very generous with computers and monitors. Of course, they had to be very high quality monitors as well. (Technologist #2)

I think at one point it was just that there weren't really enough access points to the system and some of the monitors weren't particularly up to par with regard to the quality of the image. (Physician #4)

The way it is working now is really good. It was slower before because it was a separate -- you know, you had to access a separate computer program. (Physician #1)

Initially when I was introduced to it, it was a little bit more cumbersome to actually access the films. You had to go in separately for PACS, but now you can enter the PACS process through the MediTech system. So that makes it actually quite a bit easier. It's all set up through one. (Physician #2)

Another limitation identified was the migration from the regional to the provincial PACS environment.

In Corner Brook before we went provincial PACS, we had the best system you could possibly ever want. It was beautiful how it works, and everyone who came there, be it locums from Ontario or overseas, or wherever, thought it works really, really well. Now since we've gone provincial PACS, we've taken a step back..... Now that they've gone -- like, as part of the provincial PACS implementation in the province they are getting rid of local servers in the hospitals and PACS has significantly slowed down in terms of how quickly the images come up on our screen (Radiologist #2)

It is slower because it's archived in St. John's or whatever, but I don't find it to be a big deal. (Radiologist #4)

...with the provincial wide PACS, we have a lot of issues with patients -- like, our coding is different, or the patient sometimes if they're in Grand Falls, for instance, and they don't put their middle name in and they come here and their middle name is put in their charts here, then the computer thinks of it as two different patients. So we try to pull up things from Grand Falls or Gander and the computer doesn't recognize it because they think it's two different people.(Technologist #1)

Not really. There was a bit of an issue there (slow down), but I think it's all ironed out now, but it wasn't a big deal (Technologist #1)

Well, if you go to Eastern and you get a chest x-ray, and you go to Western and you get a chest x-ray, and they're both named something differently, then when you're looking for -- if you go into the PACS, to the provincial view, and you want to bring up all chest x-rays or all x-rays of the chest for you, then depending on the way the language has been put in, they're not necessarily there... (Provincial PACS Project Manager)

Limited access to PACS by physicians outside the hospital environment was also identified as a limitation.

I think the challenge here for IT is actually getting the access out there to different physician's offices. It's out there at the site and certain specialist's offices, but it's a lot more difficult -- like, I don't know that the infrastructure is there for the VPN access, all the little doctor's offices out in the region. (DI Manager)

And a lot of them have clinics in small sites where there's not necessarily a hospital or a place that has x-rays done, but they see a patient at a clinic and then the patient goes to the hospital to have their x-rays done, but they can't view the x-rays at their clinic, they can only view them in the hospital. (DI Director)

I don't have the statistics around it, but there are even some physicians outside of the hospital system that would have access to the PACS via web client. If you step outside Central or Western, it all depends on how far they are with their own technology, their advances, their architecture changes, the new software that they're installing, and some of them are very, very behind in this. (HIN Director)

Now when the provincial strategy is further defined and shown to the province and there's an opportunity for physicians to get an EMR system inside their hospitals and there may be some funding towards it, you'll see a mad rush, but right now it's the cost. (Provincial PACS Project Director)

Training

When PACS was implemented in Newfoundland and Labrador, the "train the trainer" approach was adopted by the majority of PACS sites. This approach involved one or more permanent staff being trained in PACS by the vendor, and then these people would then train other staff, until the site had several staff trained in PACS. In interviewing key stakeholders to find out how this training went, it became evident early on that the three main groups of end users (i.e., radiologists, physicians, and technologists/PACS Administrators) had different opinions on this issue.

Radiologists

The training provided to radiologists was not considered adequate by most radiologists' interviewed. The main challenge reported was that the train-the-trainer approach did not provide training at the level of detail the radiologists would need when using PACS.

I think it was very frustrating for some people because the people that were initially trained didn't always have the same questions to ask as some of the radiologists, so they wouldn't have anticipated what to learn from the person training them. (Radiologist #1)

Like, if you ran into trouble, call (PACS Coordinator) or whoever it was at the time and say, look, I'm having this trouble with "x", "y" or "z" and if they couldn't solve it on the phone, they'd show up and help you out. It didn't seem too bad, actually. (Radiologist #4)

I think the issue was people weren't shown what (vendor) policy was, they want to train the trainer, but what the radiologists wanted was -- each radiologists actually would have preferred to have had time with the trainer. (Radiologist #1)

So they'd come and they'd spend a couple of hours with you in your office to update you on what was new in the software packages, and to make sure that you were using it to its fullest capability. (Radiologist #2)

Not everybody was clear on how to set up things, and some people are much better at using IT and computers than others. So I think as things changed, we probably should have input more education, being made more aware of what the changes are, and how you can use them to your benefit. (Radiologist #1)

I can't say it was an optimal implementation from that point of view with regards to training, but the training was made available. (Radiologist #3)

Training was quite good. You got the help that you needed and you often would have to fit into their program because they couldn't fit into yours, but it was very good. I got all the access to information that I needed and any time I had a problem, I found people very helpful. (Radiologist #4)

I don't see a problem with that, but I think they'll get much more comfort levels and buy in from the radiologists if they do more hands-on radiology training individually with each radiologist. (Radiologist #1)

Physicians

There was very little positive feedback from physicians interviewed with respect to PACS training. There was consensus among this group that there was very little, if any, training provided.

Like, nobody has really sat down and said this is how you use PACS for myself. I just was unaware of any kind of teaching or anything that went on around that. I just use what I have figured out myself. (Physician #1)

All the supports that are put in place initially when new technology comes sort of disappear pretty quickly afterwards. (Physician #2)

I'd say the training was minimal, but it's a fairly intuitive system, most everybody is used to using web-based things. (Physician #3)

I get around that by having residents or somebody else who are using it daily attach themselves to me while I'm manipulating the images, but certainly there was very little hands on training done for myself. (Physician #4)

I remember showing up one day it was there, and the guy that was working with me said, look, there's PACS, here's your login, and we just kind of figured out how to use it. That's classic for physicians. We're not very good at kind of getting together, taking an hour, sitting down and doing an in-service. I don't remember any training on it. (Physician #5)

I think the training was pretty organized. As residents, we were just given a set time to train for it, and we did the training. If we had questions, we had people to *go to answer the questions. Yeah, I think implementing it went pretty smoothly from a resident point of view, anyway. I never noticed any big problems with implementation. (Physician #6)*

I don't recall there being any great teaching on it, especially in terms of teaching how to use different windows and are we using the right settings and that kind of stuff. It was kind of just there. (Physician #7)

There was no formal training from what I can remember, unless there was something available and I missed it. (Physician #1)

I think the whole issue of the training and support was certainly a challenge. I can recall this being discussed at multiple sort of administrative meetings and so on with regard to lots of users are finding it difficult to access the system and manipulate the films and so on, and there didn't seem to be any easy way to get up to speed on it. That was a problem that was felt generally, as far as I can recall. (Physician #4)

There was very little actually on the ground activity in terms of disseminating detail about it. (Physician #5)

Yes, it was extremely haphazard. I never got trained by any trainer, as I mentioned. I just had the ten minutes with the person in radiology. I did feel that was inadequate and certainly I wouldn't think that it maximized my use of the system because of that. (Physician #4)

<u>Radiology Technologists/PACS Administrators</u>

There was agreement among the radiology technologists and PACS administrators that the training provided for PACS was excellent.

The training went very well. We had a lot of support from IT Department and everything went on schedule which was perfect because when you send out information and try to inform everyone in a region that on certain dates things are going to change, like, I think it's important for things to go on schedule because it gives people confidence in the system. I thought that went very -- well, everything went on schedule. It was perfect. (PACS Administrator)

Yes, we had two people went away to train and then we had a classroom set up and they'd bring up "x" number of steps at a time and they'd go over stuff. We had our own computer set up. Everybody had their own computer. It went over really well. (Technologist #1)

Actually, no, that went really well. Like I said, it's really user friendly, and they sent someone to this site that spent a day with us and they were available for phone calls and they still are, and it's really been easy, not a problem. (Technologist #2)

Oh, train the trainer was excellent. We have two what we call master trainers. They took on basically the training of the majority of staff and physicians, and myself... We have two master trainers and backup because we had to have someone manning the telephone to answer questions or to help people through because it was such a big project. (PACS Administrator)

4.5.5 Lessons Learned

Key informants were asked what take away messages or lessons learned they would consider important to convey to other sites undertaking an implementation of PACS. The three main messages identified included: 1) the need for sufficient in-house resources to support the implementation, 2) buy-in from senior management, and 3) that adequate planning and training is provided for any new technology/system installed prior to PACS going live.

In-House Resources

The lessons learned included: 1) having qualified people on site to deal with issues, 2) having a phased-in implementation approach, 3) recognizing that PACS is not just a radiology system, and 4) planning for the involvement of the hospital's maintenance department.

I guess having people on site who are well trained and having more than one person, on site to deal with problems with PACS as they come up on a day-to-day basis. (Radiologist #2)

I think the issues I would caution people about are just on the implementation phase to be sure that there's enough support for the introduction of the system, that there's enough points at which it can be accessed and that the users are made aware of how to get access to the system and use the images effectively. (Physician #4)

I would tell him to make sure that he has his password is working and that he's got access, first of all, and that it works, and that if it doesn't work that there's someone on call, especially if it's brand new, 24/7 to help him with it because Emerg will functionally stop if there's no way to read x-rays. (Physician #6)

Well, I'd suggest that they do a lot of planning ahead and have a lot of staff support, and to implement bit by bit, one modality at a time, and basically to have the staffing and the people trained, like, train the trainer, that type of setup. For us, we had 24-hour support, either cell phone or pager for the first year of PACS because it is a big change and it's a lot to know and a lot to learn. (PACS Administrator)

Challenges for us internally, purely IT perspective, from a resource perspective, it brought a lot of new equipment into our region that we had to (a) install; and (b) support. It was a change to our Helpdesk model because this was probably the first real-time production application that we had in place now. So certainly building the Helpdesk model around that was a challenge. (IT Director)

We would tell them to not underestimate the resources that this project is going to take, and how long it will take. That would be my first one. It's not only DI resources. I think that's the reason we had trouble in-house because people didn't realize the amount of resources they needed to commit to DI for this project. (DI Manager)

From our perspective, that's the same piece there, you know, be prepared, make sure you got the resources lined up because -- especially depending on how aggressively you do it because you've got to -- there's going to be times when you're going to be flat out rolling out equipment, you've got to make sure that your network infrastructure is up to snuff ...(IT Director)

I mean, all of a sudden because of workflow changes in the DI Department, you might need a door on this side of a wall where you had it somewhere else before. You know, getting maintenance to move a door can essentially hold up the entire project. So getting all those dependencies all identified and plotted out is key to this. Like I say, following the vendor's implementation plan is, I think, a key success to it. (IT Director)

Planning and Training for New Technology/Systems

The overriding message when planning and training for PACS was to phase-in, and then train for, the various components of PACS. In trying to do everything at once, staff may become overwhelmed.

I would also advise him to have a gradual change from using x-ray boxes to going to PACS, so that while it's being implemented, you would have regular films printed as well as PACS films so that in case PACS didn't work, you still have the regular films until everyone is used to PACS. (Physician #6)

The implementation of a CR reader, a cassette reader, the staff really need to have that put in place and be orientated and use CR for at least a month before going live with PACS. It helps the staff get through the transition of changing their images, and that's a separate machine in itself to learn how to use and receive your images. (PACS Administrator)

What happened was we had the Radiology Information System installed here in Corner Brook and Deer Lake Clinic. I believe after we went live with those two sites in December, then we started rolling Meditech out to the other sites at the same time as we were doing PACS. So, you know, every site there was something happening. It was either Meditech or PACS, and in between that we had to teach the technologists the CR as well. (DI Manager)

Well, every site they had to get involved with CR where they hadn't before. That was a great take away message we got from our site visits. I think it was one of the hospitals in the States that did this where we talked about lessons learned, and that was certainly something came from them, but from an x-ray tech perspective, it's a pretty significant workflow change and they're -- that's just in the overall -- you know, their workload from the time they get the patient in front of the machine until *they got the image ready to hand off to the radiologist for interpretation. (IT Director)*

....it was quite valuable, being able to get out and talk to other regions that have successfully implemented these solutions, so you get to see the good, the bad, and the ugly. (IT Director)

Training occurred on an as needed and when needed basis, and most of the regions would have their own trainer. We still don't have a provincial trainer in place that could help alleviate some of those problems that could travel across the province, work with the regions. So there's lessons to be learned from all of that. (HIN Director)

Senior Management Buy-in

Buy-in should be obtained from all levels of stakeholders within the region, not just the Senior Executive. Middle management and support staff need to be aware and accept their responsibilities to the project. It is particularly important to gain support from the physician community.

Probably the one problem we ran into here at this site was our doctors weren't on side, and it kind of took the -- they kind of drifted in after. It took us a little while to get them on side and to make them realize they needed to get this for themselves. (Technologist #2)

I think if I had an opportunity now to restart this project and to be the initial owner of it, I probably would have requested a guarantee from the regions that they had a buy-in, they knew what their responsibilities and roles were in this. (HIN Director)

The biggest thing for me is getting the commitment, getting the buy in, and getting a true understanding of what the expectations are of the projects in the regions. (Provincial PACS Project Manager)

They were pleased that PACS was coming to the Western region and they were on board, but other physicians were a bit more leery, and other physicians were busy, and we just couldn't tract them down. (PACS Administrator)

The buy-in from the regions -- we were limited...trying to coax the region into ensuring that this provincial project that had a time stamp on it was implemented in a timely fashion, or we would be at the risk of losing dollars, and we take them away from their day to day operational work...nobody told these people. (HIN Director)

4.5.6 Change Management

It is critical that there is adequate expertise to follow through on a change management plan, and that this resource is confirmed before the project starts. A change management plan facilitates change, ensuring that people involved are willing, able and prepared to undertake the transition with minimal disruption. The change management plans seeks to outline activities to ensure that the affected individuals remain committed to the success of the project, understand their role in implementing the new system and related process, and successfully adopt the new work process.

The change management was a bit of an issue because the change management within -- and this is where (Vendor) learned again, and where we learned that (Vendor) hadn't done this before.... So they had -- they started out with film, then they went to a local install, and then they went to provincial. When they went to the local install, it was as smooth as silk. There were no change management issues. When they went to provincial, boom, everything went wrong. (Provincial PACS Project Manager)

Well, I think change management was a challenged area of this whole project. (Vendor) had given people the impression that they did their own change management, and it was process management, it was technology management, but it wasn't actual true change management. We struggled within our own team because there was so many people that have said they're change management experts, and, you know, we question that every day because I'm not sure I see it. (HIN Director)

4.5.7 Overall Perceptions

The overwhelming consensus by key stakeholders interviewed was that PACS enhanced both service delivery and patient care.

I mean, for me it's a great tool. I can't see anything that's really bad about it per se, you know. (Radiologist #4)

No, it's a good system, I must say. It gets rid of a lot of film and a lot of duplicate exams. (Technologist #1)

This is a wonderful system. After 25 years roughly working with chemicals and film, this is just a wonderful invention. (Technologist #2)

Like I say, we have used it now for five years so it's like second nature now. I can't imagine going back to films. (Physician #3)

I would say it's brings important clinical information pretty rapidly to where you need to use it, and I think it's a valuable electronic enhancement to clinical care, and I see it as a really important piece of the electronic health record system. (Physician #2)

I guess, overall I think it was a move in the correct direction. I think it's an improvement to the hospital and the patient care. (DI Director)

No, it was a -- from my perspective, it was a great project. I mean, we certainly enjoyed working with it. It went very smoothly. (IT Director)

I love it. The only thing I would like to say is I'd hate to go back to the film world. (PACS Administrator)

Table 4-41 presents a summary of the main themes identified in the 20 key informant interviews with respect to the PACS implementation

Table 4-42
Summary of Key Informant Interview Content

Key Informant Interview Content Summary (Part I)			
Theme	**Categories**	**Sub-Categories**	**Within Sub-Category**
Perceived Benefits	Availability of Exams	Access to Primary Exams/Reports	
		Access to Historical Exams/Exam Comparisons	
		Patient Transfers/Consultations	Reducing wait lists, overcoming adverse weather and addressing temporary staffing shortages
		Reduced Duplicate Exams	
	Increased Productivity	Improved Efficiency	
		Elimination of Chemical Processes	
		Improved Workflow	
	Reduced Report Turn Around Time (TAT)	PACS reminders	PACS Functions
		No overall improvement in turn-around-times	
		Lack of transcriptionists	Human resource issue
		Improved TAT in Emergency Room	No radiologist report
Unintended Consequences	Reduction in physician radiologist interaction	Reduced clinical feedback	
		Reduced clinical history	
	PACS Downtime	Scheduled	Problem in Emergency
		Un-scheduled	
	Recruitment	Staffing in rural areas	
	Practice of Medicine	Physicians dependent on Consults in rural areas	
	Secondary Use of PACS	Audits	Physician/radiologist competency
		Teaching	
		Research	
Gaps in the Implementation Process	Lack of expertise of vendor	First provincial implementation	Although indicated, vendor had no experience in implementing a provincial PACS solution
	Limitations with hardware and software	Lack of storage space	
		Insufficient communication lines	Slow retrieval of exams in rural areas
		Lack of access	PACS Monitors
		Computer/Monitor quality	
	Provincial PACS	System slow down	Regional versus provincial
		No provincial standards	
	Access outside hospital	Infrastructure	
		Costs	

Table 4-42 (Cont...)
Summary of Key Stakeholder Interview Content

Key Informant Interview Content Summary (Part I)			
Theme	**Categories**	**Sub-Categories**	**Within Sub-Category**
Training	Radiologists	Problems in that training was not specific enough	
		Support was available if needed	
	Physicians	Little awareness of training opportunities	
		Challenge getting trained	
		Residents more available for training	
	Radiology Technologists	Training was excellent	
Lessons Learned	In-house resources	Sufficient access	PACS Monitors
		Phased implementation	CR/DR/RIS/Meditech
		Helpdesk	24/7
		Not only IT issue	Maintenance/Nursing/ER
		Infrastructure	Existing
		Building Maintenance	Changes in structure
	Planning for new technology	Film/PACS overlap	
		Transition from film to PACS – CR training	Sufficient training
		Provincial approach	Standard training across province
	Buy-In	Senior Management	
		End users (i.e., physicians)	
Change Management	Vendor inexperience	End user expectations not met in moving from regional to provincial PACS	
	NLCHI inexperience	End user expectations not met in moving from regional to provincial PACS	
Overall Perceptions	Enhanced Service delivery	Improved productivity and efficiency	
	Improved quality of care	Timely and more accurate diagnosis	

Chapter 5
Discussion of Results

This Chapter presents a discussion of the results, organized around the objectives of the study. The chapter begins with a review of the findings in relation to the perceived benefits and challenges of PACS, the total cost of ownership and return on investment, and how this PACS implementation fits in with the overall EHR strategy for the province. The chapter concludes with a discussion of the facilitators of, and barriers to, successes identified during the implementation, lessons learned, and the challenges experienced in carrying out this evaluation.

5.1 Perceived Benefits of PACS

In reporting benefits, one must be careful in drawing broad conclusions from results derived from multiple PACS benefit studies, even if the methods and modalities under study are the same. It is important to look at various contributing factors, including the level of efficiency that existed in the film environment prior to PACS being implemented. It is logical to assume that the more efficient the film environment is, the less impact PACS will have on many of the benefit measures traditionally studied in PACS evaluations (Lepanto et al, 2006). The issue with efficiency is illustrated in a study carried out by Weatherburn et al (2000) which investigated the rate of radiology misdiagnosis in an emergency department. The rate of misdiagnosis pre PACS was 1.5%, whereas the rate post PACS was only 0.6%. This small difference raised the question: *regardless if the difference is statistically* *significant, is it clinically significant?* The 1.5% rate of misdiagnosis suggests an efficiently run film environment existed in the emergency room prior to PACS being implemented. Following the implementation of PACS there was a statistical benefit realized, evident by the drop in misdiagnosis to 0.6%, however this drop was not deemed to be clinically significant. In addition to consideration being given to the efficiency of the existing film environment, other areas requiring due diligence in isolating benefits of PACS would include the redesign of workflow, facility type and size, HIS/RIS/PACS integration, training, support staff, and patient population (Reiner et al. 2002).

The volume of exams performed in a site, and its relationship to the expected benefits of PACS, warrants discussion. While installing a $2,000,000 PACS in a site that only averages 10,000 exams per year is obviously not a practical investment for most sites, it nevertheless raises the question as to what constitutes the necessary volume of images before an investment in PACS becomes feasible. Some studies report the number of acute care beds as an indicator of imaging volume (Sack 2001; Scalzi and Sostman, 1998; Strickland 2000; Swaton, 2002; Terae et al 1998; Park et al, 2004), whereas others use the actual volume of exams (Siegel et al, 1996; Siegel and Reiner, 2003; Gaytos et al, 2003). An earlier study by Bauman et al, 1996, went as far as to state that a large PACS installation required a minimum of 20,000 examinations per year to ensure the feasibility of PACS, whereas seven years later Siegel and Reiner (2003) reported the cutoff was at 39,000 exams. In classifying sites, Cartier (1999) carried out a study in a "small" hospital that produced 15,000 exams a year, while

Hayt (2001) carried out a study in a "large" hospital that produced 116,000 exams per year. While these studies classified the size of a site either in relation to the number of beds, or the actual volume of exams, there are no agreed upon standards for such classifications. Nevertheless, such studies do raise the question as to how one interprets the benefits of PACS within the context of exam volume.

Classifying a site as a low, moderate, or high user of PACS is for the most part a subjective exercise, with no standards in place that would allow for comparisons between "like" sites. The hierarchy of exam volumes at which a site moves from one level to another is unclear, given the impact that the volume has on workflow is directly influenced by the level of efficiency that exists in the DI department. It therefore would be inappropriate to assume PACS becomes feasible only after a certain threshold of exam volume is achieved. While recognizing a certain level is needed to justify implementing PACS, there are other characteristics of the site, such as efficiency, that will ultimately impact the benefits achieved. In the Terrier Health Authority, with a total of 112,667 exams in 2006, it would be expected that the benefits of PACS would be easily identified. However, this evaluation found mixed results, which supports the contention that it can be challenging to justify the need for PACS in "low" volume sites (Arenson et al, 2000).

The perceived benefits of PACS were investigated through key informant interviews and surveys of physicians, radiologists and radiology technologists, with overwhelming support for PACS being found across all professional groups. The discussion focuses on the following benefit areas identified through the study: 1) expediting review of exam, 2) easier access to exams, 3) improved patient care/outcomes, 4) PACS functionality, 5) improved quality of reports, 6) improved efficiency, 7) improved report turn-around-times, 8) reduced hospital length of stay, and 9) professional consultations. The benefits section concludes with a discussion of those benefits found to be significantly different based on the number of years experience with PACS.

5.1.1 Expediting Review of Exam

The survey of physicians prior to the implementation of PACS in the Terrier Health Authority found the perception that PACS would reduce the time needed to review an exam had the highest level of agreement (94.0%). In the survey 12 months after PACS had been implemented agreement for this measure had decreased slightly (88.1%: $p = 0.455$). Almost a decade earlier Reiner et al (1998) also surveyed physicians pre and post PACS and reported that there was a 200% increase in the average number of exams reviewed in PACS compared to film. While Reiner asked the question in a different way, the perceived value of PACS in expediting exam review is nevertheless apparent from both surveys. This is to be expected, if for no other reason then the time saved with PACS in not having to look for, and handle film. This benefit was reinforced in the physician interviews.

I think when PACS first came in, we found it a lot easier to see the x-rays, the x-rays were clearer, and easier to get, you weren't going around looking for films, you didn't have to go to the film library to pick up x-rays, that kind of stuff. So it was definitely easier. (Physician)

Similar levels of agreement were found in the survey of radiologists post PACS implementation, with 96.3% agreeing that PACS had reduced the time needed to review an exam.

Just being able to view the images much more quickly on computer versus looking at a piece of film. You can scan through images much faster. (Radiologist)

Measuring the perceived value that PACS provides in reducing the time needed to review an exam can provide valuable information, however more robust approaches for investigating this benefit utilize observational/time motion methods. These studies invariably include a comparative element, with the time to review an exam estimated in the film environment, and then again once PACS has been implemented. Direct observation is carried out by having an independent person observe and record to a standard data sheet the events that unfold during a normal period of the work process. The time motion approach is basically the same, with added emphasis put on capturing the time required to perform specific functions along the work continuum. This type of study design was used often by Stirling Bryan in his study of PACS at the Hammersmith hospital in the UK. Bryan et al (2000) employed a pre/post observational design and found there was a statistically significant increase of 2 minutes needed to review an exam in the film versus the PACS environment, while in an earlier study also using direct observation, Bryan reported that there was no significant difference in the time between film and PACS in producing a radiology report (Bryan et al, 1998).

5.1.2 Easier Access to Exams

During the key informant interviews, physicians and radiologists frequently spoke of the benefits of PACS in providing quick access to historical exams in support of patient diagnosis. In comparing previous and current exams/reports, health professionals can investigate many clinical features such as disease progression, the presence of new clinical anomalies, or the degree of healing over time. While this current study did not specifically look at access to historical exams, the survey found that physicians and radiologists accessed exams more frequently with PACS than film (86.3% and 77.8%, respectively). However, the question as to whether quicker access to exams has any impact on improved patient outcomes has received limited attention in the literature, and for the most part still remains unanswered. An earlier study by Watkins (1999), that is still relevant today, conducted interviews of 34 clinicians in various hospital departments to determine the perceived benefits of PACS. Watkins concluded that "*In general it was felt that, (while) there was no clearly discernible influence of PACS on clinical decision-making, it was possible that the speedier access to images could have some beneficial impact*". (p. 110)

5.1.3 Improved Patient Care/Outcomes

In reviewing the literature there were no studies found that focused specifically on the impact that PACS had on improving patient care. A possible reason for this lack of research is that it is difficult to develop an objective measure for patient care in a profession where subjectivity is the norm. In an earlier paper, Bryan declared what is still true today, and that is we continue to struggle with identifying the true benefits of PACS through existing measures. *The search for the observable empirical link between the provision of compete and timely medical information and improved patient outcomes is one of the challenges of evaluation in the PACS field* (Bryan et al, 1995 p.36).

In the pre-implementation survey in the Terrier Health Authority, 87.9% of physicians agreed that PACS would improve their decision making, while post PACS this agreement decreased only slightly to 80.5% (p= 0.391). The post PACS survey of physicians in the three health authorities found similar levels of agreement for this indicator (80.0%). While this high level of agreement is comforting, it provides little indication of the actual benefit to the patient. An extensive review of the literature found no studies that reported objective measures of PACS related to enhanced patient care. All research to date has focused on either surveys or interviews. For example, Reiner administered a survey and conducted interviews in a vascular surgery department to determine the perceived value of PACS and reported "*a perceived improvement in overall* *patient quality of care among both physicians and nurses surveyed.*" (Reiner et al 1996 p. 169). A survey of physicians in San Diego, California with Web access to PACS found that 97% (39/40) agreed that access to PACS in their offices improved patient care (Wadley et al, 2002). Mullins et al (2001) administered a survey to radiology residents in Boston, Massachusetts and reported that 75% (15/20) believed that PACS improved patient care. In contrast to these findings Siegel and Reiner (2003) concluded that a decrease in physician/radiologist interaction may actually have a negative impact on patient care. "*Although this shift towards electronic communication has arguably resulted in more rapid delivery of image and report information, it is not clear whether the lack of interpersonal exchange between radiologists and clinicians may have a deleterious effect on patient care*" (p. 107).

Even today we continue to be limited to subjective approaches for measuring improvements to patient care/outcomes resulting from PACS. Care must therefore be taken in reviewing the available evidence to ensure its validity. For example, Sacco (2002) carried out PACS cost benefit analysis and reported that a reduction of lost and unread exams had led to better management of patient care. However, no evidence was presented in the paper to support this conclusion, with the link between PACS and improved patient care apparently only assumed. In investigating patient care/outcomes the challenge facing the researcher was summarized by Scalzi and Sostman (1998) "*The impact on patient outcomes is* *impossible to quantify, but we are confident our PACS will improve the timeliness and quality of patient care at New York Hospital.*" (p. 92).

An example from this current study of the challenge in measuring the benefits of PACS in enhancing patient care is found in the following comment by a radiologist speaking within the context of rural Newfoundland:

I guess in terms of patient care (in a) rural area when referring physicians want to have an immediate consultation regarding the actual images rather than having them physically transported which would take a day or more, it can be done instantaneously, so no doubt the care of the patient was definitely improved by being able to consult radiologists immediately.

If one is able to enhance patient care, it is logical to assume that this would result in improvements to patient outcomes. However, whether PACS contributes to enhanced patient outcomes is for the most part theoretical, given patient outcomes studies have two primary challenges. The first is not so much an issue with PACS, as it is with almost all patient outcome studies, and that is a robust study design would need to employ a prospective approach, which brings with it challenges of costs and timing. In most cases such studies would need to span many years before any significant differences in patient outcomes emerge, with the long study period contributing to the high costs.

The second challenge is that most PACS studies employ a pre/post descriptive design, making it difficult to isolate benefits of PACS from everything else going on in a hospital (Bryan et al 1999). Theoretically, one could carry out a randomized control trial (RCT) and assign patients from the same cohort to either a control (film) or experimental (PACS) group, and then have the same radiologists provide a diagnosis for each patient. The patients for both groups could then be followed for a set period of time to determine if a significant difference in health outcomes is observed. This type of study clearly is not practical, or ethical. From the practical side, how can we expect robust results when the profession of radiology itself is influenced so much by subjectivity? From an ethical perspective, it is unlikely we will see an RCT on the benefits of PACS, given that the broader benefits of PACS over film is universally accepted, and any such study has a high probability of achieving less benefits in the control group.

Results of the survey found that the three professional groups agreed PACS enhanced patient care in rural areas of the province. This was the case for physicians in the Terrier Authority, pre (93.9%) and post (92.9%) PACS, radiologists across the island post PACS (100%), and technologists in the Terrier Health Authority, pre (100%) and post (100%) PACS.

Interestingly, the interviews provided little support for the claim that PACS enhanced patient care in rural Newfoundland and Labrador. A possible reason for the lack of support revealed during the interviews was that there is no quantifiable evidence that a physician/radiologist can reference when speaking to the benefits of PACS to rural patients. An interesting finding, in that the health professionals believe in the benefits of PACS to rural patients, but have difficulty articulating what they are. This finding must also be viewed within the context of the physicians interviewed, the majority of which were based in hospitals. It might be expected that rural physicians working in a community practice would have first hand knowledge of the benefit of PACS to their patients, unfortunately no one from this group who were contacted agreed to an interview. A possible explanation for the reluctance of general practitioners to be interviewed was that they may have had little experience with PACS, and thus felt they could offer little insight into this technology. This lack of experience may be related to their lack of remote access to the HIS.

It is also possible that many of the health professionals interviewed in this study viewed the benefits of PACS to rural patients from the clinical perspective. That is, did the rural patient achieve a better health outcome because of PACS? In most cases radiology does not require immediate decision making, and as such, it is difficult for a health professional to say that PACS (versus film) definitely resulted in an improved health outcome. Many times the economic (e.g., less travel for patient) and financial (e.g., reduced patient transfers) are used as substitute measures for improved patient outcomes.

5.1.4 PACS Functionality

The study of enhanced functionality available through PACS may provide a proxy for patient outcomes, in that, at least in theory, enhanced PACS functionality would support the clinicians' ability to provide more accurate and timely diagnosis, which in turn would lead to better health outcomes. The superior functionality that PACS provides over film in supporting diagnosis was evident from the surveys, where physicians in the Terrier Health Authority agreed PACS tools improved the quality of the radiologist report (81.3% pre PACS; 90.5% post PACS: $p = 0.313$).

The study of PACS functionality, and its impact in supporting diagnosis, has received limited attention in the literature, and what is published is primarily from studies employing surveys. Hayt (2001) reported that radiologists had positive comments concerning PACS with respect to magnification and image adjustment, but whether this was felt to result in better patient outcomes was not investigated. In an earlier study, Watkins interviewed radiologists and ICU clinicians and found functions related to magnification and contrast allowed enhancements to the image (Watkins 1999). The fact that only a few older studies were found that looked at PACS functionality, and none in the last few years, leads one to believe there is little interest in the research community in studying PACS functionality. That is, with the technology available today, it is difficult to conceive of a situation where the functionality available through PACS would not be an improvement over film.

What has occurred over the last 20 years is that technology has caught up, and ultimately passed the expectations of clinicians with respect to image quality/manipulation in the PACS environment. Understandably, there was reluctance on the clinicians' part to use digital images when PACS first came on the market in the early 1980s (Arenson et al, 2000), as change was slow to occur, and the technology at the time was not perfected, lending itself to much criticism. As the technology improved, vendors were able to incorporate much of the feedback from early adopters into next generations of PACS. Problems with storage space, speed, image quality and functionality have long been resolved from the technology perspective (Cowen et al, 2007; Busch and Faulkner, 2005; Ortiz and Luyckx, 2002); the cost for this functionality is now the challenge (Reddy et al, 2006; Bryan et al, 1999). Nevertheless, we now find that PACS functionality is widely accepted as the "gold standard" for diagnostic tools in the radiology environment, and will no doubt continue to be so for many years to come.

5.1.5 Improved Quality of Reports

The majority of radiologists across the three Health Authorities post PACS agreed that the quality of their reports had improved (88.5%). In interpreting any measure that looks at the quality of a radiology report, the reader needs to recognize that such measures are mostly subjective. Although there is some discourse on improved report quality, the previously mentioned subjectivity inherent in the radiology profession does not support the development of unequivocal evidence that PACS improves the quality of the radiology report. That said, in one of the few studies that looked at PACS and its impact on the radiology report, Reiner (2002) concluded that PACS provided diagnostic benefits over film, however the benefits realized were dependent on the type of exam reviewed (e.g., brain versus pelvic). For this current study the ability to access historical and current exams/reports more quickly, and the additional functionality available through PACS, translated into the majority of physicians surveyed agreeing that PACS has improved their ability to make decisions regarding patient care (80.0%), and improved their overall efficiency; 83.9% for physicians versus 96.3% for radiologists. The accumulation of all perceived benefits of PACS has no doubt contributed to the majority of radiologists supporting the concept that the quality of their reports had improved since PACS was implemented.

5.1.6 Improved Efficiency

The measure of efficiency is interesting, given efficiency is sometimes confused with productivity, and it is increased productivity which is often touted as a major benefit of PACS by the research community (Redfern et al, 2002; Reiner et al, 2000; Reiner et al, 2002; Andriole et al, 2002; Marquez and Stewart 2005).

Efficiency is defined as the ratio of output over input. In the case of PACS the radiologist may become more efficient if he/she is not delayed in looking for film because the exam is available at multiple locations, 24 hours a day, seven days a week. However, efficiency should not be confused with productivity or effectiveness; productivity is related to efficiency in that it is a measure of output per unit of input over time, whereas effectiveness measures the ability of a specific task to produce a specific result.

In this current study, results from the survey found both radiologists and physicians felt that PACS had improved their efficiency, with this perception being re-iterated in the key informant interviews:

So it would take sometimes hours to have a look at x-rays and discuss it with the radiologist, whereas now you get it within seconds basically. I mean, it's amazing how much time it saves. (Physician)

Although, it is possible that some physicians confused increased efficiency with increased productivity.

I mean, it literally takes seconds to get your images in front of your eyes. That's a huge thing, obviously. The way that increases your productivity during the day you can't really calculate I wouldn't think. (Radiologist)

In an early survey of physicians in a nuclear medicine department it was reported that PACS had expedited exam completion time in 25 of 102 bone scans performed (Williams et al, 1997), while a study in a radiology department found that PACS saved radiologists time and allowed more efficient retrieval of archived exams (Lou and Huang, 1992). Note that both studies investigated time saved (i.e., efficiency), and not what was done with this saved time. Ortiz and Luyckx (2002) state that increased efficiency occurs when "*more clinical information is available to radiologists and when referring clinicians have quicker access to imaging examinations and the results of these imaging studies*" (p. 18). Improved efficiencies for radiologists would allow for more exams to be reported, thus improving productivity by increasing patient throughput. This of course only holds true if there are enough patients waiting for an exam to fill the gap brought about by the increase in productivity. A small hospital that normally completes all exams in the film environment with no wait list would not necessarily benefit by an increase in radiologist efficiency. That is, they may simply finish their daily workload earlier with PACS than film. If that is the case then the question becomes what do radiologists/technologists do with this "free" time? A similar question was raised by Redfern et al (2002) in studying the relationship between increased productivity achieved by technologists and the financial savings resulting through implementation of PACS. "*Although these improvements in productivity may be realized, cost savings can only be realized if this time savings can be used to image an additional patient or to accomplish additional tasks.*" (p. 158). Of course, this is not an issue for hospitals in large urban areas, as patient volumes generally exceed any increases in productivity.

5.1.7 Report Turn-Around-Times (TAT)

While this study provided subjective evidence that the efficiency of physicians and radiologists improved, the objective evidence suggests efficiency, as measured by report turn-around-time (TAT), did not always improve. In fact, TAT in some sites increased after PACS had been implemented in the Terrier Health Authority. However, as noted earlier it is important to recognize that there are many external factors to PACS which can impact on report TAT's, such as facility type and size, HIS/RIS/PACS integration, training, support staff, and patient population (Reiner et al. 2002).

5.1.7.1 Terrier Health Authority

An analysis of the data obtained from the hospital information system at Hospital_A found that all six modalities under study experienced a significant increase in report turn-around-time (TAT) for the 12 months following the implementation of PACS. This increase, as measured by the average TAT per month, was not entirely attributable to the initial high TAT's for those months immediately following implementation. That is, it would be expected that longer TAT's would be experienced immediately following the implementation of PACS given the inexperience of users. A study by Keen (1999) concluded that radiologists needed about 2 months to get used to PACS, yet in most cases the average monthly TAT at Hospital_A was just as high, or higher, in later months than those immediately following implementation of PACS. This evidence contradicts the results of the post PACS survey administered in the Terrier Health Authority, which found that 68.3% of physicians and 100% of radiologists agreed that report TAT had improved with PACS.

While there may be several reasons that contributed to the increased report TAT post PACS at Hospital_A, an ongoing shortage of transcriptionists is believed to be the primary cause. There is no voice recognition system at Hospital_A and all reports are recorded to a stand alone recording system by the radiologists. At the time of the study this system consisted of a high end tape recorder that was not interfaced with the hospital information system (HIS). A transcriptionist reviewed the audio tape and typed the draft report directly into the HIS. The radiologist then reviewed the draft report in the HIS, made the necessary changes, and signed off on the report electronically. With a shortage of transcriptionists, there was a delay in preparing the draft report for review by the radiologist. The following comments by radiologists highlighted this issue:

We are, as you know, having a major problem at the moment with transcriptionists, so this is hindering our ability to turn around time to eventual signed report...

The problem that we're having problems with the last six months, of course, is largely transcription.

They should have, but in actual fact, there has been a major problem in dictating because of the stenographic problems they have been having, and I am sure you are quite aware of those, and if you're not, others will also advise you of that.

It is unlikely that any two studies investigating report TATs will be the same. Katto et al (1995) studied total time for the radiologist to complete the examination, whereas Reiner et al (2001) looked at the time from when the patient arrived in the examination room to the time the exam was ready for the radiologist to review. A study by Kuo et al (2003) found reporting time was significantly longer after hours than during the regular day. Upon investigation, the reason found for this difference was there were no radiologists available 24 hours a day, seven days a week. In somewhat of a unique study, Marquez and Stewart (2005) did not look specifically at PACS when investigating improved turn-around-times. In that study, PACS had been implemented four years previously and was operating fine, however the Radiology Information System (RIS) and the voice recognition system were outdated and not efficient. The study looked at several modalities and found that, following the implementation of a new RIS and voice recognition technology, report turn-around-times improved significantly for all modalities.

The Marquez and Stewart study points to an important issue with respect to PACS evaluations, and that is there are other factors that need to be considered besides PACS when investigating benefits. One needs to look at the entire enterprise, rather than PACS as a stand alone system. Inamuar (1998) suggests the evaluation of PACS needs to look at the interaction between PACS, the Hospital Information System (HIS), and the Radiology Information System (RIS), and how these systems interact with other information systems within the hospital. Foord (1999) concludes "*Installing PACS has very wide implications and it is important that these are well understood within the organisation and that acquiring a PACS is not seen as like buying another piece of imaging hardware, which has little functional impact on the radiology department and hospital as a whole. Nor must PACS procurement be allowed to be an Information Technology led procedure. PACS is a whole hospital investment which will change many people's working practices. Its selection and implementation must involve all the groups it will affect and this demands a corporate approach.*" (p. 100). Of note, unlike this current study, none of the previously mentioned TAT studies reported on the issue of exam type (i.e., outpatient versus inpatient), therefore it is unknown if the type of patient had any influence on the report turn-around-times reported from those studies.

Of interest, five of the six smaller peripheral sites in the Terrier Health Authority experienced decrease in the report TAT's following the implementation of PACS. Upon further investigation it was determined that the most likely reason for this decrease was that before PACS was implemented, these sites would batch all their non-urgent exams (i.e., film) taken over a 2-3 day period of time and then send them to Hospital_A via taxi for interpretation and reporting. Following the implementation of PACS these exams were now available immediately to the radiologists at Hospital_A for reporting, thus eliminating the time previously taken in having the film transported over the road.

An important point to consider when looking at report TAT's is that all sites within the Terrier Health Authority, with the exception of Hospital_A, have relatively small volumes of exams performed annually. To put this in context, the total exams within scope performed at the 6 peripheral sites in the Terrier Health Authority for the year under study was only 35,011, ranging from 1,134 to 16,727 per site. Adding in the volume of exams from Hospital_A (n = 77,656), the total volume of exams for the entire Terrier Health Authority was only 112,667.

5.1.7.2 Mastiff Health Authority

In the Mastiff Health Authority there were three hospitals for which TAT data was collected pre and post PACS implementation. Hospital_H carried out 97,922 exams for those modalities within scope, Hospital_I 73,428, and Hospital_J 6,505.

Hospital_H: Hospital_H provided report TAT data pre and post PACS for the following modalities: CT Scan, echocardiography, MRI, nuclear medicine, general radiograph and ultrasound. All modalities, with the exception of nuclear medicine, experienced a reduction in average TAT for the three months pre PACS compared to the 12 months post PACS. Similar to Hospital_A in the Terrier Authority, Hospital_H also experienced issues related to a lack of transcriptionists. However, given the larger size of Hospital_H compared to Hospital_A, the impact of a reduction in transcriptionists was partially absorbed by existing resources. In addition, the administration at the Hospital_H introduced short-term measures to address the delay in TATs, including increasing overtime and contracting with retired transcriptionists.

We ended up with 10,000 reports waiting for transcription here a couple of months ago, and we've had to put a blitz in trying to get extra people on and do overtime, and we still have a major amount left. We're down to around 2,000 now, but at any one time there are 2,000 examinations waiting for dictation at the moment. (Radiologist)

Although there were improvements in TATs for reports following the implementation of PACS, there were still concerns that workload would continue to increase to the point where TATs would again increase to unacceptable levels. Given this concern, the Mastiff Health Authority has indicated they will be reviewing options for purchasing voice recognition software for their larger sites.

They're (Mastiff Health Authority) actually at a point now where they've made a proposal to their senior exec to actually purchase this (voice recognition), so they feel they're at a stage now that they need to move ahead. The advantage is that the software has actually improved. (Provincial PACS Project Manager)

Hospital_I: At Hospital_I, exams within scope included: CAT scan, echocardiography, nuclear medicine, general radiograph and ultrasound. Only TATs for nuclear medicine and general radiographs experienced a decrease from pre to post PACS, whereas the average TAT for the other three modalities remained statistically the same. In investigating why some modalities experienced a decrease in TAT, while others did not, no one cause was identified. The problem the researcher had in carrying out such investigations is that administrative databases are limited when one wants to study cause and effect, and with the events occurring two years in the past, many of the professionals interviewed could not recall specific details from that period. However, one explanation put forward was a likely reduction in human resources (i.e., radiologists and transcriptionists) available, either through retention or illness, for extended periods of time for the year that TAT data was collected. During these times of staff shortages it is possible that the reporting of some types of exams were given priority over others. Another reason may be specific hospital policies which dictate what exams are reported first:

It's (Report TAT) been reduced for various imaging modalities. It's uneven. I think they must have policies, which I'm not aware of with regard to how quickly they address certain types of imaging procedure. For example, there's a difference between general x-ray, CT scans, MRI, etc. (Physician)

Hospital_J: Hospital_J is a psychiatric hospital that also provides general radiographs to the general public through an out-patient setting. Over the study period there were 6,505 general radiology exams performed at this site, with a decrease in report TAT found from pre to post PACS. Hospital_J has two technologists on staff, and no radiologist. In the film environment, a radiologist would visit Hospital_J twice a week to report on all exams taken since the previous visit. In the PACs environment the technologists now only needs to call a radiologist at one of the other sites and let them know that the exam is now posted on PACS and request a consult. The ability to post exams on PACS for external review was the most significant factor in reducing report TATs at Hospital_J.

Again being a site without a radiologist, our x-rays would have to wait until a radiologist visited us and that would be twice a week someone would come to this site and read all our x-rays, and now pretty much they're dictated the next day. (Technologist)

In discussing TATs in relation to PACS, care must be taken in drawing conclusions, and to recognize the importance in putting the perceptions of health professionals within the context of their hospital environment. In the survey across the three health authorities, 88.9% of radiologists agreed that PACS had improved report turn-around-times, while only 71.1% of physicians felt this was the case ($p = 0.047$). This difference in opinion may be the result, at least in part, in that the TATs measured in this study were based only on out-patient exams, and used the posting of the draft report (not final) on the HIS as the endpoint. Even using this restricted definition, this study found mixed results across the two health authorities with respect to improved TATs. When asked their opinion in the survey on TATs, it is possible that physicians and radiologists included both in-patient and out-patient exams, and considered the signed (final) report as the end point. If the more specific definition of TAT was used to collect data in this study, which included the "signed off" report, then the average TATs would have been significantly longer in this study.

Another issue to be considered is what constitutes an acceptable TAT? The measure itself may be objective, however its interpretation is very subjective and can include many factors, such as the urgency of the event, the type of exam, hospital policy, staffing levels, exam volume and service environment (e.g., emergency department versus a chronic care unit). To put this into perspective, is a TAT of 150 hours any different than one of 200 hours? As one radiologist pointed out to the researcher in follow-up to this issue, there is a big difference between statistical and clinical significance, and while there might be a statistically significance difference in an average TAT of 150 hours and one of 200 hours, as a physician treating a patient the reduced time of 50 hours in the context of 200 hours may not be clinically significant. The issue of clinical versus statistical significance was also discussed earlier in the context of efficiency and the rate of radiology misdiagnosis in an emergency room (Weatherburn et al, 2000).

5.1.8 Reduced Hospital Length of Stay (LOS)

A patient's length of stay (LOS) was investigated through the survey to determine the perceived benefit of PACS in reducing the LOS of hospital in-patients. The literature is sparse on this topic, and what is published is for the most part split on whether or not PACS actually reduces hospital LOS. In a study of the financial benefits of PACS, Bryan et al (2000) stated "*We conclude that there is no convincing evidence of a PACS induced change in the length of inpatient stay and, hence, estimate no change in costs from this factor .*" (p. 795). Conversely, Sacco et al (2002), who also carried out a cost analysis of PACS, concluded "*Moreover, better management of radiological units provides improved handling of clinical information, resulting in reduced time to initiate clinical action, with reduction in average length patients day and improvements in overall health outcomes.*" (p. 251).

In studying PACS within the context of LOS, one must consider what PACS could contribute to such an outcome. Obviously, PACS would support more timely access to exams and reports by physicians, thus allowing for more timely diagnosis and treatment course, which in turn would theoretically support the reduced LOS hypothesis. One might even consider the fact that PACS reduces the need to re-order exams because the original is not available, although the results of the physician survey did not find strong support for this benefit (65.0%). Examining the broader issue of LOS, there are many factors external to PACS which can play a part in how long a patient remains in hospital. Such factors would include hospital policy, physician practice, type of hospital (teaching versus non-teaching), and services provided (e.g., orthopedics). Within the boundaries of PACS, we find that the difference in time to diagnosis in film environment, compared to that of PACS, is generally measured in hours, not days. The consensus among those health professionals interviewed was that the length of stay was not significantly impacted by PACS.

I don't think for the average person it would make any difference in length of stay because it doesn't -- it makes you more efficient at doing your job day to day, but work was always done before in terms of what -- you know, even if it was on film, they still make the diagnosis. In terms of hours saved, I guess, more than days, I don't see how it would affect length of stay. (Radiologist)

Further evidence that PACS did not have a clinically significant impact on hospital LOS was found in the results of the survey of physicians. The pre PACS survey in the Terrier Health Authority found that 65.5% of physicians agreed that PACS would reduce LOS; agreement dropped to 40.5% ($p = .044$) for the post PACS survey. This statistically significant decrease suggests that the high expectations of achieving reduced LOS did not persist following the implementation of PACS. The post PACS survey of physicians across all three Authorities found similar low levels of agreement that PACS reduces LOS (44.2%).

5.1.9 Professional Consultations

It is important to distinguish between two types of consultations that can take place between physicians and radiologists in the PACS environment. One type of consultation are those that take place between sites and usually involve a physician to radiologist interaction. If a physician has the ability to consult with a radiologist located off-site via PACS, such communications would support more timely diagnosis. The second type of consultation are those that occur within a site, and can either be a physician to physician, or a physician to radiologist consultation. Results from this study indicate that much of the benefit of PACS is achieved by supporting physician-to-radiologist consultations between sites. A major benefit of these site-to-site consultations were reduced patient transfers, and while only moderate agreement was found for this benefit in the survey of physicians' post PACS (66.4%), reduced transfers were frequently noted as a benefit of PACS during the key informant interviews.

Now most orthopedic surgeons, I understand, use a web-based version of PACS and they sit in front of their computer and they say give me the patient's name, they type it in, they look at the film and they say, no, you don't need to send that to St. John's, I'll see it in clinic in two weeks, put a cast on it. In the old days, they used to have to send everything into St. John's because they couldn't see the films themselves, right (Physician).

Similarly, results from the physician survey in the Terrier Health Authority found 84.8% of physicians pre, and 81.0% post PACS, agreed that PACS had facilitated consultations with other clinicians and radiologists. And while the questionnaire did not differentiate whether the consultation was between sites or within a single site, the key informant interviews suggests it was the between site consultations that PACS facilitated.

Once in a while, like, one of the doctors will come to me and say PACS was great the weekend, I didn't have to transfer a patient out to St. John's, I just sent the images or whatever. (DI Director)

While there was considerable support for PACS providing facilitation of consultations between sites, the reverse was found concerning consultations between physicians and radiologists within a site, with such interactions decreasing following the implementation of PACS.

I guess the thing that maybe radiologists are finding that people are coming down less frequently to see them, and sometimes having that extra input because the clinical history provided on the requisition may not actually be the appropriate or detailed enough to actually help with the actual film review process. (Radiologist)
Before PACS, many staff physicians would come down and we'd have consultations over films and so on. That doesn't happen any more now. (Radiologist)

The only negative thing I can see is that from a physician's point of view there's less consultation with the radiologist because before you would be forced to go to the Radiology Department, you would actually go to the radiologist office and discuss the patient and discuss the films, whereas now everything is so quick and the reports are coming back so quick, there's not as much interaction. (Physician)

The observation that PACS contributes to a reduction in consultations between a physician and a radiologist within the same site is well documented within the literature. No longer does the physician need to walk to the radiology department to review an exam or report, which many times led to a discussion with the radiologist. Naul and Sincleair (2001) reported "*A tendency for less interaction* *among radiologists and other physicians in institutions using PACS is another potential disadvantage. This decline may arise because multiple viewing stations around the clinic or hospital reduce the likelihood that physicians will visit the radiology department.* (p. 5). Redfern et al (1997) concluded "*When a PACS workstation is in use in the clinical area, consultations with radiology decreases.*" (p. 429). The multiple access points to images throughout the hospital, as well as a general increase in report TAT's are the main reasons for the reduction in physician/radiologist consultations. It is likely these consultations will continue to decrease as technology improves and access to PACS becomes more widespread within and outside the hospital. It is becoming more common now for physicians to consult radiologists only for those cases which are considered complex.

5.1.10 Previous Experience with PACS: Benefits

The number of years experience with PACS and its impact on perceived benefits was investigated. The only cohort that provided sufficient numbers to support this type of analysis was the survey of physicians in the three health authorities post PACS (n=335). As noted previously, past experience with PACS was derived from responses provided to two questions specific to PACS experience. Unfortunately, there were not enough responses in the 0-1 experience category for this cohort to be analyzed, thus it was included with the < 2 years category. The resulting three experience categories were: 1) no previous experience, 2) < 2 years, and 3) ≥ 2 years experience. When asked if their efficiency has improved with PACS, 73.1% of physicians with no previous experience agreed, while

87.8% with <2 years experience, and 88.5% with ≥ 2 years experience felt this was the case ($p = 0.022$). This result suggests that the PACS learning curve for physicians in this study leveled out sometime around year 2 of experience with the system. This may appear to be an excessively long time, however it is supported by the S-curve transition theory (Atwell 1992) which argues organizations need extended periods of time to adapt to new technologies. Reiner et al (2000) in his study of PACS in an outpatient setting reported "*The 2-year gap between the implementation of filmless imaging at Baltimore Veterans Affairs Medical Center and the time of data collection was considered to allow for the S-curve transition period, which occurs when new technologies are adopted. This is the time required for staff to accommodate the new technology and effectively achieve a new equilibrium" p. 166.* Nevertheless, this is a considerably longer time than that for radiologists, which as noted previously was approximately 2 months (Keen 1999). This is plausible however, given radiologists use PACs every day, whereas physicians only use it periodically.

A majority of agreement was also found when physicians were asked if PACS has improved their ability to make decisions regarding patient care. For this measure, 68.8% of physicians with no previous experience with PACS agreed that PACS improved decision making, while 85.9% with <2 years experience, and 80.6 % with ≥ 2 years experience, felt this was the case ($p = 0.026$). This finding suggests that as physicians become more comfortable using PACS, they feel they can provide improved patient care.

5.2. Perceived Challenges of PACS

The perceived challenges of PACS were investigated through key informant interviews and a survey of physicians, radiologists and radiology technologists. The following discussion focuses on the following perceived challenges of PACS identified through the study: 1) access to PACS, 2) image quality, 3) PACS functionality, 4) system support, and 5) training. The discussion concludes with a review of those challenges found to be significantly different based on number of years experience with PACS.

5.2.1 Access to PACS

In the survey of physicians across the three health authorities, 29.2% agreed that they have inadequate access to PACS viewing stations, almost double that of radiologists (14.8%: $p = 0.109$). Not surprisingly, the challenge most often cited was that they cannot view the patient's images at their bed side, with 68.3% of physicians across the three health authorities post PACS implementation agreeing this was the case. While this limitation might be considered a gap in the implementation plan, it must be viewed within the context of what is affordable and practical. It was never the intent of the Provincial PACS Implementation Plan that monitors/viewers would be made available at the patient's bedside. This would simply be too costly, not only from the technology side, but also from the facility's management side, given changes to the bedside environment would be needed to accommodate the monitors. In reviewing the literature, several studies were found that reported the benefits of accessing PACS from departments outside the radiology department, including Intensive/Critical Care Units (Ravin 1990; Sterling et al, 2003; Cox and Dawe 2002; Watkins et al 2000; Horii et al 1994; Kundel et al 1991), Emergency Departments (Redfern et al, 2002), Surgery (Reiner et al, 1996), and Outpatient Departments (Andriole 2002). No studies were found that investigated the benefits of having PACS monitors located on patient wards, aside from intensive care units.

Interestingly, of the 101 negative views expressed in the comments section of the completed post PACS physician surveys, 61 (61.0%) were specific to problems with PACS access. In analyzing these 61 negative views, the issues with access to PACS were grouped under four main headings: 1) access to PACS from home or office (34.4%), 2) access to PACS monitors (31.1%), 3) access from rural sites (23.0%), and 4) access within the hospital (11.5%).

This current study found that the majority of problems reported regarding access to PACS were from physicians. Unlike radiologists, most physicians have private practices outside the hospital environment, and in many cases remote access to PACS is hindered by a lack of infrastructure and/or high costs. Recognizing that the majority of physicians maintain a work environment outside the hospital environment, in a perfect health system, access to PACS would be seamless as they move between these two environments. This however is not the case in

Newfoundland and Labrador. While the infrastructure necessary to support remote access is for the most part available in urban areas, once we move beyond these more populated areas, the ability to obtain remote access declines.

I think the challenge here for IT is actually getting the access out there to different physician's offices. (DI Manager)

And a lot of them have clinics in small sites where there's not necessarily a hospital or a place that has x-rays done, but they see a patient at a clinic and then the patient goes to the hospital to have their x-rays done, but they can't view the x-rays at their clinic, they can only view them in the hospital. (DI Director)

Even if the infrastructure is in place, the volume of patients in rural areas may not support a business case to invest in remote access technology in a physician's private practice. From the perspective of the physician the business case is not there, if for no other reason then they feel they have been able to provide efficient patient care for many years with respect to radiology using mail, fax and courier services. One also has to recognize that physicians do not consider the business case for remote access based solely on the value of PACS being available. There are many other information systems that a physician may want access to (e.g., laboratory, demographics, hospital pharmacy, etc.) in the delivery of services from their office. To expect that remote access to the HIS in rural Newfoundland will come become routine simply because PACS has arrived is naïve. The broader issue of maintaining the same level of patient care in rural areas that is available in urban areas will need to be addressed before remote access in rural and urban areas finds balance.

5.2.2 Image Quality

The quality of the image viewed over the Web was cited as a problem by both physicians (49.5%) and radiologists (45.0%) post PACS. Although the issue of the image quality on PACS workstations was raised, it was not as pronounced; 28.1% for physicians and 11.5% for radiologists. Image quality is very dependent on the type of monitor on which the image is viewed. Diagnostic (i.e., PACS) workstations, which are the most expensive monitors, are generally located in radiology departments for use by the radiologists, whereas clinical workstations, which are less costly, have less functionality and produce lower quality images, are located throughout the hospital and are mostly used for comparison and viewing by physicians (Naul and Sincleair 2001). As far back as 1999, it was reported in a study at the Hammersmith hospital in the UK that image quality in PACS had significantly improved, as indicated by 93% of physicians being satisfied or very satisfied with inpatient image quality, while 91% were satisfied or very satisfied with outpatient image quality (Bryan et al, 1999 p. 469). Pillings (2003) surveyed various health professionals at the Norfolk and Norwich University Hospital in the UK and asked "*How do you rate the quality of the images on the image review workstation*". Using a scale where "1" meant very poor and "6" meant very good, all 95 respondents selected response between 4 and 6. Although the issue of image quality in PACS has been addressed through advancements in technology, such advancements come with a price, whether it is measured in financial or technical terms.

There's always issues with quality of equipment, right. That's probably our biggest issue. (Physician)

5.2.3 PACS Functionality

Problems with Web-based PACS functionality were reported by 45.5% of the radiologists, whereas only 11.5% felt functionality was a problem on PACS workstations. As previously noted, PACS monitors are high end viewers which are usually located in the DI department for use by radiologists, whereas workstations provide more basic functions and are for general use by physicians. Slow image retrieval over the Web was identified by 31.2% of physicians and 54.5% of radiologists ($p=0.025$). Given radiologists are more frequent users of Web-based PACS than physicians, it would be expected that the problem of slow Web-based image retrieval for this group would be more pronounced. The most likely reason for this issue with image retrieval is that during the time of the survey the Terrier Authority had recently been linked to the provincial PACS archive. Previously these images were stored locally and retrieval times were almost instantaneous, but now they were part of the provincial PACS system. Although there were some initial problems with slow speeds on the provincial PACS they were eventually addressed.

There was a bit of an issue there (slow down), but I think it's all ironed out now, but it wasn't a big deal (Technologist)

5.2.4 System Support

There were no major challenges identified specific to the system administration of PACS (e.g., passwords, logging on, etc.), however there was some concern expressed with the availability of system support. With respect to physicians, 34.9% felt system support was inadequate, whereas 39.0% of radiologists felt this was the case. Recognizing that 35%-40% does not constitute a majority, this finding nonetheless indicates that there were still issues with system support following one year of PACS operation. This study was not designed to determine if these issues were specific to PACS, or more systemic across the hospital, however it is perceived that the issue of system support for PACS was indicative of a broader issue with IT support.

All the supports that are put in place initially when new technology comes sort of disappear pretty quickly afterwards. (Physician)

I think the whole issue of the training and support was certainly a challenge. I can recall this being discussed at multiple sort of administrative meetings and so on with regard to lots of users are finding it difficult to access the system and manipulate the films and so on, and there didn't seem to be any easy way to get up to speed on it. (Physician)

Challenges for us internally, purely IT perspective, from a resource perspective, it brought a lot of new equipment into our region that we had to: (a) install, and (b) support. It was a change to our Helpdesk model because this was probably the first real-time production application that we had in place now. So certainly building the Helpdesk model around that was a challenge. (IT Director).

Support from an IT perspective in the PACS environment has been addressed to a certain degree in the literature, however there are distinctions to be made as to what type of support is being referred to. There are the regular technical aspects of PACS, which would involve specific problems (or questions) around the PACS software itself. This would include many areas, but basically the question would be of the form "How do I do ….?" or "How come it won't do….?". The vast majority of these problems are resolved by the PACS Administrator, a relatively new position created specifically for PACS, and found in almost every site with a PACS installation. In this study, the issue of system support looked at the broader view of IT support, which in some cases was totally independent of the PACS.

While no major IT support issues were identified, this study did find some minor complaints around access, Web speed and downtime. Access is for the most part driven by policy/budgets, and generally is not considered an IT issue, and the issues with Web speed have been previously discussed. In this study the issue raised regarding downtime was specific to scheduled downtime and was mostly noted by emergency room physicians. PACS requires periodic shutdowns for maintenance, which are always scheduled after normal working hours. This is convenient for the majority of physicians in the hospital, but is not the case for emergency room physicians. In some cases it was reported that PACS was shut down for maintenance at 6:00 p.m. on a Friday night, a time referred to by emergency room physicians as "fight night". The timing of these scheduled shutdowns are mostly dictated by hospital administration, as it is less costly to have vendor consultants come in during reasonable hours, than when a hospital is least busy, which in most cases is during the early morning hours on a weekday.

5.2.5 Training

Whether or not training provided for PACS end-users was adequate depends on the professional group. Only 7.1% of radiology technologists felt they received inadequate training in the new technology, compared to 34.6% for radiologists and 47.0% for physicians. When radiologists were asked about training during the key informant interviews, the point frequently made was that the people trained in during the "train-the-trainer" phase were not trained to answer specific questions relevant to radiologists. That is, trainers were trained in the basic functionality of PACS, and not to the level that would benefit radiologists.

I think it was very frustrating for some people because the people that were initially trained didn't always have the same questions to ask as some of the radiologists, so they wouldn't have anticipated what to learn from the person training them. (Radiologist)

Physicians on the other hand were a group that readily admitted they were difficult to bring together for training. Unlike radiologists, who work out of a hospital, physicians for the most part have community practices in addition to admission/discharge privileges with a hospital. Getting a physician to block off a couple of hours of their free time to go to the hospital for PACS training was not a process that found much success. This no doubt contributed to the high degree of agreement (47.0%) physicians had when asked if they received inadequate training in PACS.

We're not very good at kind of getting together, taking an hour, sitting down and doing an in-service. I don't remember any training on it. (Physician)

5.2.6 Previous PACS Experience: Challenges

Additional analysis was conducted to determine if there were any differences in the perceived challenges based on past experience with PACS. Of the 12 questions that measured challenges, only one was found to have a significant difference across the three levels of experience. The question asked physicians was whether they experienced inadequate Web performance (speed) when accessing PACS. Just over 40% of physicians surveyed with no previous experience with PACS agreed Web speed was inadequate, compared to 15.9% of those with less than 2 years, and 36.1% with more than 2 years ($p=0.002$).

The difference in agreement found for physicians with less than two years PACS experience compared to those with more than two years is interesting. As discussed previously the learning curve for physicians is longer than that of radiologists, and the S-Curve Transition theory further suggests that the learning period is approximately two years for an organization to fully accept new technology. However, the increase in agreement that Web speed was inadequate by physicians with more than two years cannot be fully explained by the S-Curve Transition theory. While recognizing that Web speed is only one small part of PACS functionality, it is nevertheless interesting that Web performance was found not to be acceptable for new users, was for those with less than two years experience, and then reverted back to not being acceptable for those with more than two years experience.

A possible contributor to this difference in agreement across the three levels of experience is that those physicians with less than two years of PACS experience have not yet become accustomed to having remote access, and the slow speed experienced is accepted as part of having access outside the hospital. In contrast, the more experienced physicians (> 2 years) are at the point where remote access in itself is not enough, and they now want improvements to Web speed. It is also possible that the experience measure derived from the survey is not a reliable measure given the different PACS "go live" dates across the province. Recall that for this study the measure "experience" was derived from two questions asked in the survey: "*Have you had experience with PACS prior to this implementation project*?" and if the answer was "Yes", a second question asked "*How many years of PACS experience have you had*?" Deriving an "experience" variable in this manner would theoretically work well in the Terrier Authority, given this region never had any PACS until the installation in December 2005, and the first year's experience would be fresh in their minds when completing the questionnaire 12 months post implementation. The argument could be made that this also holds true for the Mastiff Authority, even though their major sites went "live" in the fall of 2004 and the survey was administered in January 2007. In the Spaniel Authority however, PACS had been around for eight years prior to the post PACS survey in that region and memories would had faded considerably by the time they completed the questionnaire. However, on further investigation, it was determined that only 55 of the 335 physicians (16%) responding to the post PACS survey were from the Spaniel Authority. This number was not sufficient to fully explain the difference in percent agreement found over the three levels of experience.

A separate issue that may impact on this measure is that some sites in the province have insufficient bandwidth connecting them to the province's health information network, and this certainly would result in slow Web speed. Unfortunately, this theory cannot be tested given in order to protect the privacy of the respondents, the only demographic information collected from respondents was the Health Authority in which they worked. Therefore, whether issues with slow Web speed were dependent on the site location (i.e., low or high bandwidth) was not known. The province is currently working to enhance connections for sites without sufficient bandwidth.

5.3 Total Cost of Ownership (2005/07): Province

An analysis of the total cost of ownership of PACS in Newfoundland and Labrador was undertaken so that other jurisdictions considering PACS technology could be provided with a high level estimate of total costs. However, it was realised very early on in the study that it would not be possible to determine the total cost of all PACS implementations at the provincial level. The process of implementing PACS across the province began many years before partnership discussions with Infoway started in 2003. In fact, before Infoway was established, Newfoundland and Labrador PACS had its genesis in the Spaniel Authority as far back as the late 1980's, and concluded with the Mastiff region implementing PACS at two of the largest hospitals in the province in the summer of 2004. In total, these regional installations provided PACS capability to approximately 70% of the Newfoundland and Labrador population. As it is not known what the total costs were for PACS systems installed over the period 1998-2004, the total costs of PACS ownership at the provincial level focused only on the period 2005-2007.

Soon after the partnership between Canada Health Infoway and the province was formed, a provincial PACS project scope was undertaken to identify what would be required in terms of functionality and resources if the province was to realize a true provincial PACS system. The focus of the scoping exercise was to identify where enhancements to existing PACS in the province were needed, as well as sites where PACS would be installed for the first time. The project scope was undertaken by the provincial Ministry of Health, took a year to complete, and cost $175,000. After this work was completed a significant amount of due diligence took place between representatives of the Ministry of Health, the Regional Health Authorities and Canada Health Infoway. At the conclusion of this process the total financial commitment agreed upon was $22,837,711 (Table 5.1), of which the province would contribute $12,266,256 (54%), while Infoway would provide $10,571,455 (46%). The costs for hardware and software totalled $19,723,527 (86.4%), with $3,114,184 (13.6%) allocated for professional services.

Table 5.1
Total Cost of PACS Ownership (2005/07)
Newfoundland and Labrador

Project Cost Item	**Cost**
Hardware/Software	$19,723,527
Project Management	$3,114,184
Total	$22,837,711

The Infoway/Provincial PACS implementation began in March 2005 as a project directly managed under the Ministry of Health. The Provincial PACS Project Manager, who was an employee of the Ministry of Health, worked with the PACS vendor and the regional authorities in managing the various PACS installations/enhancements across the province. Around this same time the Centre for Health Information completed the implementation of the province's Client Registry, and was in the final stages of securing an agreement with Infoway and the provincial government on the project plan for the provincial Pharmacy Network.

Given the Centre's mandate to implement a provincial EHR, and its existing capacity developed through work on the Client Registry and Pharmacy Network, the Ministry of Health transferred full project management of PACS to the Centre in July 2006. Subsequently, the PACS Project Manager position became a full-time employee of the Centre within the Health Information Network (HIN) Department. This development is important as it relates to the total cost of ownership, given that the Centre had been building internal EHR project management expertise since 2002. With the transfer of this resource to the Centre there was no need to set up a separate project management office for PACS in Newfoundland and Labrador. With the Centre taking ownership of PACS, the expertise at the Centre simply moved from the Client Registry and Pharmacy projects to the PACS project.

It is important to note that when the Centre for Health Information first started work on the Client Registry in 2002, the strategic direction taken was to develop capacity for EHR project management from "home grown" resources, with expertise being cultivated through internal hires and specialized training of current staff; the use of private consultants was to be minimized wherever possible. While such a strategy required a commitment for long-term funding from government, it did allow the Centre's project management office to minimize professional fees, which can be significantly higher than that of an internal resource, as well as better control cost over-runs that are common in large IT projects. Given this internal capacity, there were significant human resources provided to the PACS project by staff at the Centre which were considered in-kind contributions, costs that will not show up in any financial documents related to PACS in Newfoundland and Labrador. In speaking to the Director of HIN at the Centre, a conservative estimate of these in-kind costs, which includes office space, administration and human resources, would be $400,000 per year for two years. As shown in Table 5.2, the total estimated cost of implementing/enhancing PACS in the province of Newfoundland and Labrador through the Infoway/Provincial partnership (2005-2007) was almost $24 million. Of interest, the researcher requested budget information on other PACS projects from Infoway so that comparisons of total cost of ownership might be carried out. This request was denied given Infoway had signed agreements with other jurisdictions not to share this information with third-parties.

Table 5.2
Total Cost of PACS Ownership (2005/07)
Including NLCHI In-Kind Contributions
Newfoundland and Labrador

Project Cost Item	**Cost**
Hardware/Software	\$19,723,527
Project Management	\$3,114,184
Sub-Total	\$22,837,711
In-Kind (NLCHI)	\$800,000
Total	**\$23,637,711**

5.4 Total Cost of Ownership (2005-2007): Terrier Health Authority

In 2006, the population of the Terrier Health Authority was 79,034 and encompassed an area of approximately 40,000 km^2. At the time of the study there were a total of 266 acute care beds in the region, with 186 (65%) being located at Hospital_A, the main hospital in the region. There were also six (6) smaller hospitals and several community health centres dispersed throughout the region.

The Terrier Health Authority had no PACS technology prior to the Infoway/Provincial partnership, and while this removes costing contamination from previous PACS implementations, it does require partitioning of some provincial costs to the Terrier Health Authority. This process required estimates from staff within the Centre's Health Information Network (HIN) Department when providing costs for scoping and project management for the Terrier Health Authority. With these caveats in mind, the Centre's HIN Department estimated total costs for project management provided to the Terrier Authority at $200,000 over two years. Combined with actual costs for hardware, software and vendor fees the total cost of ownership of PACS in the Terrier Health Authority as shown in Table 5.3 was estimated at $4.1 million, with annual costs of $229,000 for maintenance and licensing fees.

Table 5.3
Total Cost of PACS Ownership (2005/07)
Including NLCHI In-Kind Contributions
Terrier Health Authority

PACS Item	Cost
Hardware	$2,398,790
Software	$932,270
Vendor Fees	$400,900
Data Storage	$200,000
NLCHI In-Kind	$200,000
Total Cost	**$4,131,960**
Annual Maintenance $229,000	

5.5 Return on Investment: Terrier Health Authority

As noted in the discussion on the total cost of ownership of PACS, it was not possible to separate out the costs associated with PACS implementations in Newfoundland and Labrador prior to the Infoway partnership. Therefore, carrying out a return on investment (ROI) analysis of PACS following the 2005 PACS implementation looked only at the Terrier Health Authority, as this region had no PACS prior to the 2005 implementation.

In the Terrier Health Authority costs associated with the film environment were supplemented with PACS implementation costs in undertaking the PACS ROI analysis. One approach used to calculate the cost per exam in the PACS environment was based on constant payments and a constant interest rate. This analysis estimated the cost per PACS exam at $8.50, which is similar to the cost $9.4 per exam previously calculated in the film environment (see Table 4-33). While this approach is more in line with normal accounting procedures it does assume a long planning horizon (10 years), limited volume increases, and a constant discount rate (6%). Even by spreading out the costs over ten years, this analysis provided marginal financial benefit. For this accounting method in particular, the primary reason for the high costs per exam in the PACS environment will continue to be the annual maintenance cost, which constitutes approximately 36% (2,290,000/6,298,559) of the total exam costs for sites under study in this evaluation.

A second accounting approach was employed and used only basic accounting procedures in estimating the cost per exam in film and in PACS. For this method, all costs were adjusted to 2005 dollars assuming a 4% inflation rate, with PACS hardware depreciated over 6 years at a 15% decline rate.

In the first full year that PACS was operating in the Terrier Authority (2007/08), the estimated cost per exam, excluding implementation costs, was $6.4. This compared to $7.4 per exam in the last year of the full film environment (2004/05). However, excluding implementation costs is not recognizing the true costs associated with the

PACS environment, and therefore this estimate has little validity. When we include implementation costs, the adjusted cost per exam in the PACS environment increases to $11.8 per exam. Interpreting this difference requires an understanding of how these estimates were derived. In looking at all the components that make up the total cost of PACS, the most expensive is hardware. The accounting approach used in this study was to treat PACS equipment costs as part of the ongoing maintenance cost that is depreciated over a period of 6 years. However, depreciation of PACS equipment does not allow for capital costs to be entirely eliminated, given that the hospital will most likely need to replace or update the equipment at some point. In light of this consideration, it is estimated that in the Terrier Health Authority it will cost an average of $2.65 more per exam in PACS than in film for the first six years of PACS operation.

One reason a return on investment will not be realized with PACS in the Terrier Health Authority is that the installation is not based in a single hospital, but rather it is spread across 7 sites spanning a vast geographical area. This regional set-up required additional costs, such as PACS software, workstations, and licensing fees that would not normally be experienced with a single installation. Nevertheless, high equipment costs combined with low exam volumes will continue to be two of the reasons why a financial return on investment is not possible for many PACS environments. The literature reports financial savings from PACS are the result of reduced film library staff, storage space, chemicals and transportation (Chan et al, 2002; Maass et al 2001; Bick and Lenzen, 1999). However, these savings will only become important if the reduction in savings realized is sizeable in proportion to the entire operating budget for the DI Department. For example, if it costs $750,000 annually to operate a DI Department, and by implementing PACS at a cost of $4,000,000 results in a savings of $200,000 annually in film costs, then a financial return on investment is not possible, unless as noted earlier, the time horizon is lengthy.

The other area of savings relates to increased efficency/productivity within the Diagnostic Imaging department. As noted previously, there are few opportunities for increasing revenues through increased productivity in Canada, given our publicly funded and administered health care delivery system. Although there is an increasing use of private imaging centres in other jurisdictions in Canada, it is unlikely they will be established in Newfoundland and Labrador in the foreseeable future. Also, in Canada, a patient is not obligated to go to the image centre and pay out-of-pocket for the service, even if their physcian is promoting the private clinic. Patients can go to any hospital and receive the service for free, as long as they are a resident of Canada. In Canada, the main benefit of increased efficency/productivity in the PACS enviroment is that a radiologist can turn around reports in a more timely manner, provided that other resources in the reporting process are maintained. With this increase in productivity, it is possible for more exams to be reported, and while not generating additional revenue, it may eliminate or delay the hiring of additional staff if patient throughput was increasing and threatening to negatively impact on timely reporting. This would be an issue for larger hospitals located in urban areas that have continuously increasing patient throughput.

One of the components of savings resulting from implementing PACS is reduced staffing in the film library. In the Terrier Authority there were only five film staff, four of which were eliminated when PACS was implemented. However, a new and more senior position of PACS Administrator was also created, bringing the total PACS staff compliment at Hospital_A to two (2). Of note, the Diaganostic Imaging department at Hospital_A was, by all accounts, operating a very efficient film environment. As discussed previously, PACS provides limited benefits to an already efficiently run film enviroment, especially when exam volume is relatively low. Using Hospital_A as an example, a total of 75,000 exams were maintained annually by 5 film staff. If this DI Department was not efficient, we might expect 10 film staff being needed to keep up with demand, and following the implementation of PACS we could eliminate as many as 8 of these 10 positions. Such a reduction in staff would contibute significantly to the overall financial savings attributable to PACS. Obviously the actual savings realized at Hospital_A from staffing reductions are not of that magnitude, given only three positions were eliminated.

Human resource savings are magnified as the volume of exams increases, or the efficiency decreases, or both. A hospital generating 250,000 exams might require a film staff in the range of 25-30, yet only need 5 following the implementation of PACS. We would expect the implementation of PACS to result in significant savings from a staffing perspective in sites having 10 or more film staff, with additional savings realized if the current film enviroment is not efficient. Therefore, when estimating the financial savings from PACS, it is not enough to look at exam volume.

One must also look at staffing levels in the film library, and whether the DI Department is already an efficiently run film program.

As noted previously, the most significant contributor to the total cost of PACS, and the main reason for not realizing a financial return on investment, are equipment and maintenance costs. In the Terrier Health Authority total cost of PACS was $4.1 million, of which $2.4 million was for hardware (58%). In addition to hardware costs, annual licensing and maintenance costs usually run about 10-15% of capital costs, which in the case of the Terrier Health Authority came to $229,000 per year. One potential opportunity to reduce PACS equipment costs is for multiple sites to partner and offer a joint request for proposals (RFP), thus taking advantage of any economies of scale. However, this potential was not realized in this study. The overall cost for the provincial implementation/enhancement of PACS was $24 million, not an insignificant amount, even nationally. Yet even with this significant amount of expenditure, there were no savings realized, and the considerable costs of the PACS equipment resulted in most hospitals in the province not achieving a return on investment. Until costs of PACS hardware, software and licensing fees comes down in price it is unlikely, except in the largest urban hospitals, that there will be any financial return on investment for the majority of PACS implemented in Canada.

The financial return on investment resulting from PACS is perhaps the most debated "benefit" of PACS in the literature. The debate centres on whether or not sufficient savings and/or revenues are generated to justify the considerable implementation costs for the PACS technology. It is doubtful that there will ever be one single study that becomes the yardstick by which the feasibility of future PACS installations are measured. This is because the business models in radiology departments, and the philosophies that exist as to what constitutes a financial benefit of PACS, differ considerably between studies.

With respect to business models, there are studies that consider PACS as an opportunity to increase revenues (Kim et al, 2002; Worthy et al 2003), whereas other studies investigate PACS from the perspective of costs savings (Reddy 2006; Fang et al, 2006; Srinivasan et al, 2006; Goldszal et al, 2004). With respect to what costs are included in a financial analysis, they can be categorized as direct or indirect costs (Becker and Arenson, 1994). Direct costs are those immediately involved in operating the DI department and would include costs such as the film supplies, chemicals, courier fees, staff, equipment, maintenance fees and storage space (Chan et al, 2002; Maass et al 2001; Bick and Lenzen, 1999). Indirect costs would include intangibles such as enhanced patient care, improved patient outcomes, reduced LOS and duplicate exams, and improved clinician satisfaction (Maass et al, 2001; Bryan et al, 1999). If we include other variables such as facility type, patient population, and the level of pre PACS site efficiency in the financial model, then it is obvious that each study will have its own unique features, and thus provide little in the way of opportunities for comparability with other studies.

The real challenge is not in determining revenues and/or savings, although both are important and given they are direct benefits, relatively easy to measure. The challenge is determining indirect benefits of PACS, that even today continues to elude meaningful measurement. That is, how can one quantify in financial terms benefits such as improved patient care or outcomes, improved access or clinician satisfaction? In spite of the 25 plus years of PACS research, there still is no consistent evidence that supports the financial benefits across the many diverse environments in which PACS operates. Sites having high exam volumes, inefficient film environments, and opportunities to generate revenues, offer the best likelihood of achieving a financial return on investment. In contrast, the Terrier Health Authority had a moderate exam volume, a efficiently run film environment, and no opportunities for generating revenue. This environment resulted in the cost per case analysis in Terrier Health Authority concluding that (unless the planning horizon is lengthy), PACS is more expensive to operate, based on total implementation costs, than when film was used.

5.6 PACS and the Provincial EHR Strategy

The establishment of Canada Health Infoway in 2001 paralleled the work already underway in Newfoundland and Labrador with respect to the EHR. In the late 1990s, the province recognized the value of an EHR, but did not have the financial resources to fund it. Although the strong return on investment put forward for the Client Registry secured $3.4 million in funding, the resulting Registry was not a robust system and had limited functionality. When the "best of breed" partnership with

Infoway was formed, it not only infused an additional $5.4 million into enhancing the Client Registry, it more importantly established the Centre for Health Information on the national stage as a leader in EHR development and management.

Building on the success of the Client Registry, in May 2002 the provincial government approved funding of $800,000 for the Centre for Health Information to undertake a project scope for a provincial pharmacy network. The project scope was presented to government in June 2003. At the same time the Pharmacy project scope was being prepared, negotiations between the Centre and Infoway were taking place towards a partnership on a pharmacy network implementation. The project scope was subsequently approved by government and a second partnership with Infoway was formed. On January 31, 2005 the Centre for Health Information and Infoway issued a joint RFP that would address the deliverables of a pharmacy network set out in the project scope. On July 30th, 2006 the Centre for Health Information began implementation on the Pharmacy Network in Newfoundland and Labrador, with an expected "go live" date in early 2009. Total costs for implementation of the Pharmacy Network are estimated at $25 million.

On the surface it appeared that the phased approach presented in the Benefits Driven Business Case (1998), which called for the implementation of the Client Registry and Pharmacy Network as first deliverables, was being realized. However, on closer inspection it was clear that, aside from the Client Registry and Pharmacy Network being identified as early implementations in the BDBC, there was considerable deviation from the Centre's original EHR implementation plan. One of the main differences was that the BDBC called for the implementation of the Client Registry and the Pharmacy Network to begin simultaneously in the first year. In reality the "best of breed" Client Registry was completed in 2005, whereas the implementation of the Pharmacy Network only commenced in July 2006.

With respect to PACS, discussions began between the Ministry of Health, the Regional Health Authorities and Canada Health Infoway back in the summer of 2003. While PACS was identified in the BDBC as the third building block of the EHR, and was to follow the implementation of the Client Registry and Pharmacy Network, the Centre played a very limited role in these early PACS discussions. The provincial PACS initiative was led by the Ministry of Health, with the Centre's role at the time expected only to be administration of the project funding. During this time, two significant documents were developed by the Ministry of Health related to the vision for PACS in the province. The first being a report released in August 2004, entitled "*As Is Analysis, To Be Vision and Gaps*", which presented current capacity and gaps with respect to PACS in Newfoundland and Labrador. In March 2005, the Ministry of Health released a second report entitled "*Newfoundland and Labrador Phase II Project Charter*" which put forward the implementation plan for PACS in the province with a vision of having PACS support *Any patient, Any image, Any report, Anywhere and Anytime* (A^5). In February 2006, the Minister of Health announced that Canada Health Infoway would be contributing $10.5 million towards the realization of a provincial PACS in Newfoundland and Labrador, with the provincial

Government committing an additional $14 million, of which $10 million was considered in-kind, and reflected the significant investment that the province already had committed to PACS over the period 1998-2004.

In February 2006, full project management of PACS was transferred to the Centre along with the position of the Provincial PACS Project Manager. With the transfer of PACS project management, the implementation, operation and maintenance of the three core building blocks of a provincial EHR were now under management of the Centre for Health Information. The status as of March 2008 is provided for these three information systems:

Client Registry (2002 - present)

The "best of breed" Client Registry became operational in 2005. It is currently being upgraded to support the integration with the provincial Pharmacy Network. Most of the enhancements were completed in March 2008, with the interface to the Pharmacy Network expected to be completed by the summer of 2008.

Pharmacy Network (Expected "go live" December 2008)

The Pharmacy Network team is in the final stages of design work. Vendors, who must adapt their applications to support the Newfoundland and Labrador Pharmacy Network, will be testing their systems by the end of 2008.

Provincial PACS (2007 – present)

The PACS project "officially" became a provincial PACS in November, 2007 with the last of the four Health Authorities migrating to the provincial database. Authorized users province-wide can now collect, store, manage, send and view radiology reports and images electronically.

Looking back on the BDBC, there were very few details provided in 1998 beyond planning for the Client Registry and Pharmacy Network, and perhaps to some extent PACS, although even then digital imaging was linked with the laboratory information system under the module *Personal Diagnostic Service History*. The remaining phases identified in the BDBC were either not specific to any one system (e.g., Physician Practice Pattern Profiling), or were additional functionalities to a system already identified (e.g., Personal Medication Regimen).

If we look at Newfoundland and Labrador's strategic EHR plan that was in place in 2007 we find similarities with early phases of the BDBC, but considerable difference beyond the first three core systems (Client Registry, Pharmacy and PACS). Some of the deviations, but not all, are the result of Canada Health Infoway being established. If a provincial jurisdiction with limited resources can avail of financial support from a federal agency in support of their EHR initiatives, the order of system implementation is strongly influenced by the strategic direction set by the federal agency. This can be seen in Newfoundland and Labrador, where the Laboratory Information System and

PACS were originally combined into the *Personal Diagnostic Service History*, and were to be implemented following the Client Registry and Pharmacy Network. However, funding from Infoway accelerated implementation to the point where the provincial PACS was completed in 2007, while Pharmacy is not expected to go live until 2009. As noted previously, the BDBC proposed that Pharmacy be implemented first, so that savings could be realized and re-invested in less feasible systems, namely PACS.

Deviations from the BDBC were not limited to the order of system implementation, as some EHR components currently being implemented in the province were not even considered back in 1998. The Provider Registry was not considered part of the BDBC, yet is now considered core to the EHR. Working in partnership with the Client Registry, the Provider Registry provides professional and demographic information on health care providers using the provincial EHR. The primary sources of information for the Provider Registry are regulatory organizations for licensed health providers. Currently under development, and a prerequisite for the Pharmacy Network, the Provider Registry is expected to be operational by the summer of 2008.

A second EHR component not included in the BDBC because of its poor business case, but which is now currently moving forward in the province in partnership with Infoway, is Telehealth. Telehealth employs communication technology in providing health care services to people living predominately in remote and rural areas. In 2005, Newfoundland and Labrador completed a telehealth strategy which identified five strategic directions: 1) selfcare/telecare, 2) access to specialists and specialty services, 3) chronic disease management, 4) tele-homecare, and 5) point of care learning. Two initiatives are currently approved: the HealthLine (i.e., the selfcare/telecare strategy), which is managed by the Ministry of Health, and the chronic disease management plan, which is managed by the Centre for Health Information. The chronic disease management initiative will use videoconferencing to enhance health care delivery to patients with chronic diseases in the province, primarily those geographically removed from core urban centres. The Telehealth Project has as its partners the Centre for Health Information, Canada Health Infoway, the Ministry of Health, and the Regional Health Authorities.

The provincial Laboratory Information System is now a separate project, although it is tied financially to the *Interoperable Electronic Health Records* (iEHR) project. The iEHR is a complex undertaking, but basically it will integrate the Client Registry, Provider Registry, Pharmacy Network, Electronic Medical Records (see below), Laboratory Information System, Telehealth, and PACS so that a single point of access for all these EHR functions is available to health providers. The Laboratory Information System (LIS) is expected to be the last core EHR system funded by Infoway that the Centre for Health Information will address through its EHR planning. The vision for the LIS is to provide laboratory information (current and historical) in real-time to health professionals in support of enhanced quality of patient care. Given that: 1) the LIS is the last core EHR component to be implemented in the province, and 2) the ultimate goal is to integrate all core EHR components, a decision was made by the Centre and Infoway to combine the two initiatives in an implementation plan for government. A high level planning document for the iEHR/Labs project was completed by the Centre in November 2006. The report identified the expected benefits, a conceptual solution, recommended standards, as well as a high-level estimate of the cost to implement the iEHR/Labs project in Newfoundland and Labrador. It is expected that the Centre, the Ministry of Health, and Infoway will begin formal discussions in mid-2008 on how to move the iEHR/Lab project forward.

A separate, but no less critical component to the Newfoundland and Labrador EHR is the Electronic Medical Record (EMR). An EMR is an electronic record of health information collected on a patient at point of service within the health system. This point of service is hierarchal, an example of which could be a single physician office, a clinic/group practice with multiple physicians, a hospital, or even a regional health authority. The province of Newfoundland and Labrador considers the EMR a critical component of the EHR. The Centre is currently carrying out stakeholder consultations as part of the process of developing a strategic plan for the implementation of a provincial EMR. This work is being carried out on behalf of the Government of Newfoundland and Labrador and is expected to be completed in early 2008. As of March 2008 Canada Health Infoway does not fund the development of EMR's.

5.7 Key Facilitators and Barriers to Successful Implementation

Key informant interviews and comments provided via the post PACS survey identified a number of key facilitators and barriers to the successful implementation of PACS in Newfoundland and Labrador.

5.7.1 Key Facilitators

Leadership: The Centre for Health Information had been building expertise, leadership and credibility in EHR project management in the provincial health system since it began work on the Client Registry in 2001. Over the years a level of trust has been built up in the health system, predicated on the fact that the Centre is not an entity onto itself, but a resource working on behalf of the provincial government, the four regional health authorities, and health professionals in general. This trust was instrumental in moving the PACS project through the four authorities, ultimately resulting in one of the first provincial PACS in Canada.

Stakeholder Engagement: The Centre for Health Information does not have authority to dictate activities within a regional health authority. The approach taken by the Centre is to engage all key stakeholders in the system and to secure buy-in and build champions prior to moving forward with any project planning or implementation. While planning for the Client Registry, the first EHR project undertaken by the Centre, over 1,000 stakeholders were consulted. A further 800 stakeholders were consulted during the planning stages of the Pharmacy Network. This level of engagement is significant, given the entire population of the province is only 500,000. Of note, there were no formal consultations undertaken for the PACS project, as the planning and scoping stages for PACS were carried out under the management of the Ministry of Health. When management of PACS was transferred to the Centre, the trust from the health system was a residual benefit from previous consultations carried out during the Client Registry and Pharmacy projects; many of the same people consulted in the system were involved in all three projects.

Capacity: The model used by the Centre for Health Information is to build internal capacity and minimize the use of private consultants whenever possible. This supports the transfer of knowledge from one project to the next, and facilitates the mentoring of younger, less experienced staff. When PACS was transferred to the Centre from the Ministry of Health, the Centre's Health Information Network Department had several full-time staff that had worked on both the Client Registry and the Pharmacy projects. These staff not only had project management experience, but had already established credibility and trust with the health system through these previous projects.

The Political Environment: The political environment that existed when PACS was being considered cannot be underestimated as a facilitator for the successful implementation of PACS in the province of Newfoundland and Labrador. At the time PACS was in the planning stage there were only four CEO's to deal with, all of which had a history of working together. They all struggled with delivering health services within limited budgets to small populations dispersed across vast geographical areas. With a contribution of $10.5 million from Infoway and $14 million from the province the financial restraints that previously existed were removed. CEO's were also able to address, at least in part, one of the more politically sensitive issues in the province, that being equal access to health services for residents in rural and remote areas. This positive financial and political environment ensured champions of PACS at the highest level in the regional health authorities.

PACS History: PACS is not a new technology, having been available since the 1980's. Many radiologists/physicians were eagerly awaiting the implementation of PACS as they either had previous experience in another jurisdiction, or they had talked to colleagues who had experience with PACS.

5.7.2 Key Barriers

Experience: Implementing a PACS across a province having a vast geographical area brings with it challenges not experienced in a single hospital or enterprise implementation. There was a significant learning curve for both staff at the Centre and the vendor, as neither had previous experience with such a large PACS implementation project. The importance of having internal project management capacity, as noted previously, was critical in mitigating this lack of experience at the initial stages of the implementation.

Change Management: A problem with the change management process occurred when individual regional authorities were linked to the provincial PACS. The result was that a slightly longer time was needed in retrieving exams from the provincial archive, compared to when they were retrieved from the local PACS archive. To put this in context, one radiologist put this time difference at around 3-5 seconds. The issue of the delay experienced from moving from a regional to the provincial PACS could have been mitigated simply by communicating to end-users that an increase of 3-5 seconds in retrieving an exam will be experienced once their site is put on the provincial PACS. This communication should have been sent out months in advance of "going live" on the provincial network. The underlying issue was that this 3-5 second increase was never anticipated by the project team, and therefore was never communicated to the end-users.

Equipment and Software: Concerns were initially raised by end-users that there were not enough access points to PACS, and that in some cases the quality of the image was not on par with film. These concerns were not in the majority, and for the most part access to PACS monitors was considered appropriate, and the quality of the image adequate. However, it would be interesting to re-visit this issue in 5-6 years when the Infoway investment is no longer there, and the province is the sole source for replacing aging PACS equipment. There were also some issues with the software immediately after "going live". This had little to do with PACS, but the lack of interface between the Health Information System (HIS) and PACS. The HIS used by all hospitals in Newfoundland and Labrador is Meditech, which provides much of the patients clinical and demographic data. In the early days of PACS, the physician had to access PACS and Meditech separately, causing delays and frustration on the clinician's part. Shortly thereafter an interface was installed and the physicians and radiologists were able to access PACS directly through Meditech.

Provincial Network: There are some remote sites in the province that do not have sufficient bandwidth between themselves and the provincial network, and the bandwidth they do have is expensive to maintain. This has caused some problems for these sites, given it results in delays in retrieving and sending exams and reports. This is not a major issue, as most of these sites are still pleased with the fact they can now transport exams digitally, even if the retrieval time is slower than that experienced on the larger backbone of the provincial network. This is because the time required to transport film exams was significantly longer than the time now required for PACS transmission.

Physician Buy-In: While Physician buy-in was not directly related to any specific barrier to implementation, it nevertheless requires discussion given its indirect impact on overall usage of PACS. Of all the stakeholders surveyed and/or interviewed during this study, the group most critical of PACS was the physician community. The two main issues identified by physicians were those related to training and access:

> Training: One problem with the PACS implementation that physicians identified was training in the new technology. Either they felt the training they received in PACS was insufficient, or that they received no training at all. In either case, this perceived level of inadequate training led to the belief that PACS was not being utilized by physicians to its full potential. They report using only one or two basic functions of PACS in carrying out their daily activities. That said, the physicians who took part in this study were also very upfront in saying they are the most challenging group of health professionals to train in any new technology. Scheduling a training session during their workday is problematic given their workload, and scheduling such a session on their day off has proven even less successful. This issue is not a problem for radiologists, as most are employees of the hospital, where a majority of their time is spent. Physicians on the other hand generally are not employees of the hospital, and most have private practices in the community. There is no easy solution to this, and ultimately it is up to the physician to make time to learn about PACS. The role of the project management team is to engage the physicians early in the implementation process and to customize training at a time convenient to the physician, as much as possible.

Access: Physician issues with access to PACS were not focused on access to PACS monitors within the hospital, so much as Web access to PACS outside the hospital. As noted, many physicians have private practices in the community, in addition to having admission/discharge privileges within the hospital. Without remote access they still must travel to the hospital to review exams or reports of their patients in PACS, although they can always have the report mailed or faxed to their office. This was a common frustration of physicians with PACS in the province, although such problems appeared to be concentrated more in rural areas, where IT infrastructure is less advanced, and where remote access is not always possible, even if desired. A more general frustration with remote access identified was the associated cost. Currently, physicians are provided with the software needed to access Meditech remotely free of charge, however they are responsible for purchasing their own computer and paying for the monthly internet charges.

5.8 Lessons Learned and Recommendations

Recommendations regarding key lessons learned identified by respondents are presented under the following three headings: 1) in-house resources, 2) planning and training for new technology/systems, and 3) senior management buy-in.

The Issue: In-House Resources

Considerable pressure was put on the regional health authorities and the Centre for Health Information to provide internal resources towards the implementation of PACS. Much of what needed to happen to successfully realize this implementation was unknown, given a provincial PACS had never been implemented. There were no previous large scale provincial installations to learn from, and much of what was done in the province broke new ground, not only from the technology side, but also from the project management side. These unknowns were further complicated by the fact that the vendor had little previous experience in carrying out such a large scale PACS implementation. The Regional Health Authorities also had their internal resources stretched, as it was their staff who had to communicate that PACS was coming, support the installation of new equipment (either from an IT or facilities management perspective), plan for and coordinate PACS training, and set up the help desk. These new responsibilities were in addition to their regular duties within the hospital.

Recommendation:

Planning ahead for the required internal resources is critical and needs to be considered in concert with the resources that are going to be brought to the project by the vendor. The resources of the vendor need to be confirmed prior to finalizing the contract, and penalties allowed if the vendor does not maintain these resources for the duration of the project. Consideration must be given to the local environment with respect to its ability to adjust to changing scope and shifts in implementation plans. In Newfoundland and Labrador the Centre for Health Information had internal resources that could quickly adapt to these changes and keep the project on track, and on budget. Jurisdictions without a dedicated project management resource must ensure they have a fairly deep bench within the health system that can adjust to changes in scope (i.e., scope creep) and resource requirements. It is important to recognize that these internal resources may be needed for extended periods of time (i.e., 12-18 months) and to expect delays in every phase of the implementation. A rule a thumb would have all the best planning and estimates done, have all parties agree to the scope and the required resources, and then add in a level of contingency (e.g. 20% of total budget). Given the complexity of these large information system projects, this may still underestimate the resources required.

The Issue: Planning and Training for New Technology/Systems

The implementation of PACS impacts upon many information systems in a hospital, and workflows will need to change beyond that of the radiology department. In Newfoundland and Labrador many smaller satellite sites were in scope to receive PACS, yet these sites did not have any Computed Radiography (CR) technology to generate the exam, nor a hospital information system to facilitate the flow of patient information. For these smaller sites it was necessary for staff to not only learn how to use PACS, but also how to use the CR system and Meditech. Introducing three new technologies at the same time not only presented challenges from an IT/Project Management perspective, but also for the end-users, many of which had to learn three new information systems at the same time.

Recommendations:

A phased-in approach should be employed when moving from film to PACS. If possible, allow at least one month for end users to get comfortable with each new piece of technology introduced leading up to the "go live" date for PACS.

The Issue: Senior Management Buy-in

As noted previously, the initial buy-in for PACS from the regional health authorities was at the CEO level, given the political environment was favorable to support the implementation of PACS in their region. Securing champions at the highest level of the organization is critical for any large information systems project, however it does not in itself guarantee success. The problem was that this buy-in did not filter down to the senior Directors and Managers in the health authorities, which created a difficult environment for project management staff at the Centre. The challenge that arose was that middle management in the authorities saw PACS as just another IT project thrust on their already full workload. The project team at the Centre was under considerable pressure to deliver PACS on time and on budget, whereas key people in the authorities, who needed to be on side if this goal was to be realized, did not see PACS as a priority during the initial stages of implementation.

Recommendation:

The project scope and identification of specific roles and responsibilities should be approved and signed off by the CEO, and appropriate middle management in each authority must be informed of the project prior to implementation commencing. In addition, a comprehensive communication plan should be developed and implemented before the project begins, with communications continuing throughout the implementation process. Such a plan would mitigate against mixed messages and confusion that arises as to who is responsible for specific project deliverables.

5.9 Challenges in Carrying out the Evaluation

Challenges experienced in carrying out the PACS Benefit Evaluation in Newfoundland and Labrador are discussed:

Study Design: The study design used to evaluate PACS in Newfoundland and Labrador was a pre/post comparative design. While this design is practical, relatively cost effective and ethically safe, it has several disadvantages, namely: (1) it will only identify associations (not causality), and 2) external confounders may not be equally distributed between the pre/post data collection periods. An example of an external confounder in this current study was the different resource levels of transcriptionists across the study sites. Another disadvantage of pre/post comparative design is the length of time it takes to complete. To put this in perspective, the evaluation of PACS in Newfoundland and Labrador began in June 2005 and was completed in March 2008, a span of almost 3 years. In taking such a long time to complete the study, interest in the study findings may have waned, simply because other issues have moved to the forefront. This is especially true when evaluating PACS, given the technology has been around for 20 plus years and is of proven benefit to physicians and radiologists, regardless of evidence that suggests that most hospitals in Newfoundland and Labrador did not achieve a return on investment from PACS.

The one advantage of this PACS evaluation with respect to timing was that there is a strategic plan at the Centre for Health Information to evaluate all major components of an EHR, and then bring together all this work under the umbrella of an overall evaluation of the iEHR. Within this larger evaluation framework, the researcher was part of the team that evaluated the Client Registry, and is the principal investigator on a current study evaluating the benefits of the provincial Pharmacy Network. The Pharmacy Network evaluation began in February 2006 and is not expected to be completed until late 2009. Also underway is an evaluation of an EMR pilot which is being carried out by the e-Health Research Unit at Memorial University. The researcher is also in discussions with Canada Health Infoway to lead a benefits evaluation of the proposed provincial Laboratory Information System and ultimately the iEHR. So while the extended time to complete the PACS evaluation may have taken away some of the anticipation for its results, it is still within the five-year time frames established for the broader evaluation of the iEHR in the province.

Given the long period of time to complete the study, and the multiple data collection methods used, it is not surprising the budgeted cost to carry out the PACS evaluation in the province was relatively high at $290,000. However, even this budget was not sufficient, as a significant amount of free time was provided to the study by staff at both the Centre for Health Information and the health authorities, as well as faculty involved as members of the supervisory committee for this researcher's doctoral dissertation. Other jurisdictions considering an evaluation of PACS need to be cognizant of issues relating to costs and time and select the most appropriate study design based on the available resources and the key objectives of the evaluation.

Regional Resources: Many staff in the regional health authorities were involved in data collection activities during the PACS evaluation. All of these staff had full days doing their regular job, in addition to the duties they inherited when the implementation of PACS commenced in their authority. This environment sometimes delayed the data collection process. Given the time needed to complete the study, the researcher must also expect to lose some resources in the regions due to retirement or replacement. Training of these new staff in data collection methods will need to occur. For this study very little financial remuneration (<$1,000) was necessary for regional resources used in collecting data for this study. Other jurisdictions may not have that benefit and will need to incorporate such costs into their evaluation budget.

Physician Participation: A robust evaluation of PACS requires the collection of feedback and opinions from physicians. This study saw a relatively high response rate for the post PACS physician survey (36.3%), but a much lower response when recruiting for the key informant interviews (7.0%). The challenge in recruiting physicians for an interview was primarily due to not being able to contact them directly to inform them of the study. Unlike radiologists, who work out of the hospital and have published e-mail addresses, most physicians have private practices and a personal e-mail account. These e-mail accounts are not available within the public domain, or through the Newfoundland and Labrador Medical Association. In the absence of an e-mail address, the researcher obtained the physician's business phone number from the College of Physicians and Surgeons of Newfoundland and Labrador. Of the 100 calls made, 75 messages were left with the secretary, or a answering machine, informing them of the study and requesting an interview. Two physicians were recruited through this means. In 12 of the cases the researcher reached the physician directly, resulting in three more physicians agreeing to be interviewed. The remaining 13 physician phone numbers were no longer in service, or there was no answer after three attempts to contact. An additional two physicians were recruited through personal acquaintance with the researcher. Of note, all seven physicians interviewed had admission/discharge privileges at one or more hospitals, and were knowledgeable of PACS through their work in the hospital environment. No general practitioners (GP) were recruited for the interviews.

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The Newfoundland and Labrador Medical Association reported that physicians in the province are inundated with research questionnaires and requests for interviews. This no doubt contributed to a lack of interest from general practitioners. Another possible contributing factor was that, unlike most specialists, general practitioners were unlikely to have significant exposure to PACS outside the hospital, and may have felt they had little to offer in the way of an opinion on PACS. This goes back to the lack of remote access to PACS, especially in rural areas of the province. Anecdotally, the researcher's own physician works out of a semi-rural clinic with one other physician; neither had hospital admission privileges or remote access to PACS. When asked why there was little interest in PACS, the physician indicated it was not a priority, as there is usually no problem in waiting for the radiologist report to be mailed or faxed, and they did not want to go through the added work and costs of getting remote access. In spite of the challenges in recruiting physicians for interviews, a relatively high percentage of physicians in the province completed the questionnaire. In using both key informant interviews and surveys a more comprehensive perspective of the physician community was obtained.

Administrative Data: Without question, the most serious challenge experienced in carrying out this benefits evaluation was obtaining data from hospital administrative systems for the 12 quantitative benefit measures. These administrative measures were previously developed at the national level by Infoway prior to the PACS evaluation commencing in Newfoundland and Labrador. To validate the national measures for the Newfoundland and Labrador environment, the researcher presented the 12 measures at a pre-evaluation workshop, at which time the participants were asked to confirm that the indicators were appropriate and practical, in the sense that administrative data would be available to support their measurement. There was no indication given at the workshop that there would be any significant challenges in collecting administrative data for these measures.

Of the 12 measures, only two provided any real contribution to this benefits evaluation. These were the impact that PACS had on report turn-around-times (although this measure had to be modified), and the cost per case analysis. As these two measures have been discussed previously, the following discussion focuses only on the ten for which administrative data was not available, or data was available, but the measure was no longer relevant to the Newfoundland environment. These ten measures are discussed under the following headings: 1) transition from film to PACS, 2) access to PACS, 3) duplicate exams, 4) productivity, and 5) patient transfers.

1) Transition from Film to PACS

Two indicators for which data were readily available were "Degree of Filmlessness" and "Percent Digitally Stored Exams". However, these measures were not relevant to this study given that the final implementation plan called for a complete conversion from film to digital exams the day that PACS went “live”. In fact, physicians and radiologists were informed well in advance, that the day PACS became operational no exams would be printed to film. The only exception would be those modalities out of scope (e.g., Mammograms), and special requests from patients. The value for these measures would be where sites intend to phase in PACS one modality at a time over the course of several months. In the Terrier Health Authority all six modalities in scope went “live” within days of each other.

2) Access to PACS

Three indicators were designed to measure levels of access pre and post PACS to determine if access to exams and/or reports increased following the implementation of PACS. This benefit area certainly has merit, given the many problems that exist in locating and retrieving exams and reports in the film environment. The measures developed to investigate access included: 1) number of unique clinician user accounts, 2) number of active users, and 3) number of remote users. Originally the indicator “number of unique clinician user accounts” appeared a straight forward measure, and would have supporting data. However, the IT Departments in most hospitals in Newfoundland and Labrador do not create user accounts by profession, they issue them based on the person’s name. Therefore, it would not be possible to see if physician/radiologist access increased simply by reviewing user accounts, given the accounts would include all staff in the hospital (i.e., administration, nursing, technical support, technologists, physicians, etc.). Another problem arose with user accounts when it was determined that users do not apply for a PACS account, they apply for a Meditech account (i.e., HIS), for which PACS is just one of many modules available. As noted earlier, it was not possible to track access to PACS in isolation of other information systems available through the HIS. The indicator "number of active users" suffered the same fate.

The indicator "number of remote users" did not suffer the same fate as that of "number of unique clinician user accounts" and "number of active users", given remote access to the HIS is for the most part limited to physicians. That is, nursing, technical support, technologists and most administration staff, aside for some IT personnel, do not have remote access. Based on this, the researcher was able to get a proxy measure for number of physicians remotely accessing the HIS, however as with the other two access measures, whether they were accessing PACS on the HIS was not known. That aside, as previously discussed, physicians generally have an issue with remote access given less efficient means of obtaining the radiology report (e.g., fax, mail) still are available, and for the most part are perceived as an acceptable means for accessing reports.

3) Duplicate Exams

A benefit of PACS that generates some interest in the literature is whether a decrease in duplicate (or redundant) exams occurs following the implementation of PACS (Sacco et al, 2002; Bryan et al, 1999). The theory behind this benefit is that in the film environment exams may be re-ordered because the original is not available when needed (Scalzi and Sostman, 1998; Siegel et al, 1996; Watkins 1999; Cox and Dawe, 2002). Such duplicates are costly and expose the patient to unnecessary radiation (Siegel et al, 1996; Weatherburn and Davies, 1999; Bryan et al, 1999). Administrative data for this indicator would be available if we simply defined a "duplicate" exam as a "repeat" of the same exam within a specific period of time. However, many exams are repeated for legitimate medical reasons, such as certain respiratory illnesses whereby exams are repeated in short intervals to monitor progression of the illness. Adding to the problem with this indicator was that the order entry module in the HIS overwrites the previous order, thus making it impossible to identify the previous exam type.

4) Productivity

Two measures of productivity were proposed for this study: 1) exams dictated per radiologist scheduled hours, and 2) worked productivity percent. Following a thorough investigation within the sites, it was concluded that there was no administrative data available to support these measures. This is not only true for Newfoundland and Labrador, but most other jurisdictions as well, given the low quality of workload measurement data for radiologists submitted by provinces to the Canadian Institute for Health Information. Another issue with measuring a radiologist's productivity is the cap funding model used in some jurisdictions.

Cap funding is where a radiologist is paid for each exam read and report produced, up to a certain maximum amount (i.e., the "Cap"). Once the funding cap is reached they no longer are paid for reading exams. Anecdotal evidence suggests that a radiologist's productivity decreases substantially once this funding cap is reached. In addition, when a radiologist completes their work quicker in PACS than in film, the question then becomes what to they do with this "free time".

In small sites, the use of administrative databases to measure productivity of radiologist and technologists is generally not appropriate. In such sites there is a certain amount of work to be done and the number of exams reported will not change between PACS and film; the exams just get reported quicker as a result of improved efficiency. In smaller sites there is generally no waitlist for radiology services, which was the case for most sites studied in Newfoundland and Labrador.

5) Patient Transfers

The last of the 10 benefit measures not operationalized in this evaluation was "reduced patient transfers". Again, an important indicator if one is studying the benefits of PACS, but administrative data in Newfoundland and Labrador could not support it. While the provincial hospital discharge database maintained by the Centre for Health Information can identify patient transfers to and from all hospitals in the province, it does not contain any information as to why the transfer occurred. Further investigation at the site level revealed the same problem, with Meditech not capturing this information. In Newfoundland and Labrador, when a patient is transferred from one hospital to another a hard copy physician note is sent with the patient indicating to the receiving hospital the purpose of the transfer. The note is inserted into the patient's medical chart, with only the fact that the patient was transferred from hospital "A" to hospital "B" entered into Meditech.

5.10 National PACS Benefit Measures

There was prior consideration given to the possibility that administrative data would not be available for all of the 12 Infoway benefit measures. To compensate for any gaps arising in collecting data from administrative systems, the six (6) benefit areas were also covered in the surveys administered to physicians, radiologists and technologists, and the key informant interviews. However, the dearth of supporting administrative data reported by the researcher for the Newfoundland and Labrador evaluation contributed to the decision by Infoway to revisit the issue of benefit measures for PACS at the national level. In May 2007, Infoway completed work on a national benefits framework for PACS. The framework is meant to support Infoway in moving forward with future PACS evaluations, and to demonstrate the value of their investments in this technology. The six main benefit areas of PACS would guide the work, although there was an emphasis that the framework be pragmatic with respect to the data/resources available in any one jurisdiction.

The national benefits framework proposed alternate approaches to measuring the benefits of PACS. The measures were developed within a pragmatic context, with the goal of achieving operationalizion in most jurisdictions in Canada. The indicators and methods proposed were selected based on the Newfoundland and Labrador PACS evaluation experience, an extensive literature search, and a national consensus building workshop attended by representatives of Infoway, Statistics Canada and the Subject Matter Experts (SMEs) from all six (6) Infoway EHR program areas: Diagnostic Imaging, Drug Information Systems, Interoperable Electronic Health Record (iEHR), Lab Information Systems, Public Health Surveillance, and Telehealth.

In the final report, the indicators proposed to measure the benefits of PACS were: 1) radiologist and technologist efficiency, 2) timeliness to information and timeliness of patient care delivery by referring physicians, 3) availability of diagnostic imaging services (i.e., reduced patient transfers), and 4) avoidance of unnecessary interventions (i.e., reduced redundant exams ordered). The indicators proposed to support these measures employ various data collection methods utilizing a diverse set of data sources, including: surveys, data collection sheets, patient chart reviews, administrative data and time motion studies. A summary of the indicators, associated measures and the proposed design is present in Table 5.4. The full report of the

National PACS benefits framework can be found on Canada Health Infoway's website at:

http://www.infoway-inforoute.ca/Admin/Upload/Dev/Document/BE%20Techical%20Report%20(EN).pdf

Table 5.4
Summary of National PACS Benefits Framework

Indicator	Measures	Design
Technologist Efficiency	*Time elapsed from patient registration to exam available to radiologist for interpretation* Objective measure: Exam Turn Around Time (TAT)	*Study Design #1: Exam TAT determined through recorded time checks, pre and post PACS* *Study Design #2: TAT determined through a Time Motion Study (TMS*
Radiologist Efficiency	*Time required by the radiologist to access an exam and generate the report* Subjective measure: Perceived Benefits	*Recommended that a survey questionnaire (mailed or Web-based) be administered 3-months pre-PACS implementation and 6 and/or 12-months post PACS implementation.*
Timeliness of access to information for the Referring Physician	*Time elapsed from the point of the exam completion to the availability of the radiologist report to the referring physician* Objective measure: Report TAT Subjective Measure: Perceived Benefits *Time spent by the referring physician retrieving images and reports.* Subjective Measure: Perceived Benefits	*Study Design #1: Report TAT determined through recorded time checks, pre and post PACS* *Study Design #2: Report TAT determined through a Time Motion Study (TMS), pre and post PACS* *Recommended that a survey questionnaire (mailed or Web-based) be administered 3-months pre-PACS implementation and 6 and/or 12-months post PACS implementation.*
Timeliness of patient care delivery by the referring physician	*Referring physician capacity to make clinical care decisions in a timely manner.* Subjective Measure: Perceived Benefits	*Recommended that a survey questionnaire (mailed or Web-based be administered 3-months pre-PACS implementation and 6 and/or 12-months post PACS implementation.*
Availability of DI Services in the patient's location	*Patient travel required to access DI services* Objective measure: Rate of patient transfers for DI services pre and post PACS	*Study design is a pre/post comparative analysis using a retrospective chart review as the data collection method*
Cost avoidance	*Number of redundant exams ordered*	*Study design is a pre-post comparative analysis using retrospective chart review.*
Avoidance of unnecessary interventions	Objective measure: Number of exams re-ordered pre-PACS because original was lost or missing	

Those considering undertaking a PACS evaluation can benefit from the lessons learned in Newfoundland and Labrador. In using a triangulation approach to data collection, this current study was able to utilize multiple data sources, mitigating against the risk of losing a sole source of data. As well, the importance of due diligence in determining what data is available to support the benefit measures prior to the study design being finalized is critical. While not always possible or practical, future disappointment may be averted if a small pilot is carried out specific to those measures requiring administrative data. The fact that in this study we could not investigate the impact of PACS on reducing patient transfers and redundant exams using objective data was particularly disappointing. In developing the national framework, these two measures were included as imported benefit measures, with a patient chart review recommended as the primary data collection method.

5.11 Other Provincial PACS Evaluations

One of the objectives of this study was to obtain data from other jurisdictions in Canada that were carrying out PACS evaluations. While there were no PACS evaluations that were as comprehensive as the one carried out in Newfoundland and Labrador, there were three that focused on specific areas which were of interest to the researcher. These were evaluations that had previously been completed in Nova Scotia, Ontario and British Columbia. Each is briefly described below:

Nova Scotia

In the province of Nova Scotia the evaluation consisted of a post PACS opinion survey of radiologists and physicians and a TAT analysis. Limited information on the findings of this survey were available, although it was reported that there was a very low response from physicians to the survey.

Ontario

The Thames Valley Hospital Planning Partnership in Ontario carried out a cost per case analysis and administered a post PACS opinion survey of physicians and radiologists in the following hospitals: Alexander Hospital, Woodstock General Hospital, St. John's Health Care London, Middlesex Hospital Alliance, St. Thomas Elgin Hospital, Tillsonburg Memorial Hospital and London Health Sciences Centre.

British Columbia

In British Columbia the PACS benefit evaluation was focused on the Interior Health Authority (IHA). Unlike previous PACS evaluations carried out in Nova Scotia and Ontario, the study within the IHA, in addition to administering a post PACS opinion survey, also undertook a cost per case analysis and a comprehensive study on report turn-around-times.

Data collected from these evaluations were forwarded to Infoway by each of the three jurisdictions. The researcher contacted Infoway and requested access to this data in a de-identified format for the purpose of carrying out a broader PACS benefits evaluation. This request was not approved, because the data sharing agreement signed between Infoway and the individual jurisdictions only authorized Infoway to have access to the data and report any findings. Infoway did provide the researcher with contact information within each of the jurisdictions so that approval for access to the data might be obtained at the provincial level.

In Nova Scotia the contact provided was the private consulting company that carried out the survey. Upon contacting the consulting firm the researcher was referred to the Nova Scotia Ministry of Health. Following 2-3 weeks of exchanges via email and phone calls, the Ministry of Health in Nova Scotia notified the researcher, through the vendor, that their data would not be made available to Newfoundland and Labrador. Concerns with privacy were cited as the main reason for this decision.

The same request was made to both the Ontario and British Columbia projects, with the initial response in both jurisdictions being very encouraging. Unlike Nova Scotia, the primary contacts for Ontario and British Columbia were within their respective health systems. In Ontario, it was the Privacy Manager located at the London Health

Sciences Centre and St. Joseph's Health Care, while in British Columbia it was the Chair of Interior Health Authority's Research Ethics Board. From the onset, both individuals were very supportive of a broader PACS evaluation, however they also acknowledged the potential challenges presented by the agreement between Infoway and the jurisdictions that stipulated that only Infoway would have access to record specific data collected within the jurisdictions.

As a potential solution to this issue, the researcher drafted a data sharing agreement (DSA) that set out the rules under which the researcher would access de-identified records from these two PACS evaluations. In preparing the DSA two additional challenges were revealed. The first was the draft DSA would need to be approved by the legal departments in the respective jurisdictions. While this process was not viewed by the researcher as a detriment to gaining approval, it did cause concern given the potentially long period of time in getting a legal opinion on the DSA. At the same time, who would sign the DSA on behalf of the individual PACS projects was identified as an issue. Thames Valley in Ontario encompassed eight (8) acute care sites, whereas the Interior Health Authority in British Columbia consisted of 35 sites. The question raised was whether the CEO of a health region had the authority to release de-identified record specific data collected within individual hospitals within the region. The issue of CEO authority was also forwarded to the legal Departments in the respective jurisdictions for a legal opinion.

The process of gaining access to PACS evaluation data in Ontario and British Columbia began in June 2006, and ended in January 2007 without the DSA being approved, or the issue of signing authority of CEO's being resolved. Following eight months of communicating back and forth, the researcher was informed by both parities that the request was unlikely to be approved. Thus ended any possibility of combining data from the Newfoundland and Labrador evaluation with data collected from the other three major PACS benefit evaluations undertaken in Canada as part of the Infoway initiative.

5.12 Limitations of the Study

The limitations of the study included:

1) Although a relatively high response rate was achieved for the post PACS physician surveys (36.3%), the total number responding suggests the sample was non-random. As well, significantly more physician specialists responded to the post PACS survey than that found in the overall physician population (71.6% versus 51.2%), and further, no general practitioners agreed to be interviewed. This makes it unlikely that the responses of the physicians are representative of the general population of physicians;
2) Collapsing the four-point Likert scale to two categories ("Disagree" and "Agree") resulted in a loss of more detailed information. A larger sample size would have facilitated analysis at the 4-point scale;
3) The small sample sizes for the surveys restricted the analysis to univariate techniques, thus limiting conclusions one can draw from these results. A multivariate approach would have supported the investigation of predictors of perceived benefits and challenges of the PACS system;
4) While the focus of this study was on the perceived benefits of PACS pre and post implementation, it is recognized that PACS is only one component of the broader hospital information system. While it would be impossible to evaluate PACS in isolation from the rest of the hospital, one still needs to recognize

that there are many factors (i.e., confounders) involved in the provision of radiology services to patients;

5) While the questionnaires were piloted in an earlier PACS evaluation (i.e., Thames Valley, Ontario), were vetted through the Diagnostic Imaging Expert Panel, and went through an extensive literature review, two problems with the questionnaire were still identified in this study: 1) in future studies, the questionnaire should be revised so that the question of IT support is worded to specifically address PACS IT support versus overall IT support, and 2) professional consultations specify the difference between consultations that occur within an hospital and those that occur between hospitals;

6) The lack of administrative data to support objective benefits measures limited the strength of conclusions resulting from this study. Future studies should consider pre evaluation due diligence initiatives (e.g., a pilot) to determine administrative data availability;

7) The absence of study data from PACS evaluations carried out in Nova Scotia, Ontario and British Columbia negated the potential for increased sample sizes and inter-provincial comparisons. Future EHR benefits evaluation studies carried out at the national level will need to work on breaking down these data sharing barriers.

Chapter 6
Summary of Research, Implications of Findings and Conclusion

6.1 Summary of Research

A benefits evaluation was undertaken to determine the impact that the implementation of a province-wide PACS had in the province of Newfoundland and Labrador. The evaluation was carried out on the island portion of the province with a focus on the Mastiff and Terrier Health Authorities. The Spaniel health Authority was only included in the post PACS survey. The evaluation began in June 2005 and was completed in March 2008.

This study was carried out to: 1) validate and measure the benefits arising from the implementation of the provincial PACS, 2) compare PACS benefit measures in Newfoundland with PACS evaluations carried out in Nova Scotia, British Columbia and Ontario, 3) describe the implementation of the provincial PACS within the context of other key strategies in the province, 4) document the total cost of ownership of the provincial PACS, and estimate the time to achieve a return on investment, 5) identify and describe the key facilitators and barriers to the successful implementation of PACS, 6) document the lessons learned from implementing the provincial PACS, and 7) report on the challenges encountered in carrying out the evaluation.

The evaluation was guided by the report *Towards an Evaluation Framework for Electronic Health Records Initiatives:* (Neville, Gates, MacDonald et al, 2004), which emphasizes significant stakeholder involvement at each step of the evaluation, and triangulating data where ever possible. The evaluation was designed as a pre/post comparative study utilizing project documentation, administrative data, surveys and key informant interviews as the primary data collection sources. Administrative data was collected each month for at least three months pre implementation and each month for at least 9 months post implementation. Questionnaires were administered pre and post PACS to radiologists, radiology technologists and referring physicians to measure perceived benefits and challenges with PACS, while key informant interviews were carried out at least 12-months post PACS implementation. Financial documents and spreadsheets were reviewed to estimate the total cost of ownership, and the cost per exam in film verses PACS.

The pre PACS survey found the benefits most often reported by physicians were reduced time needed to review an exam, and the opportunity for enhanced patient care in rural Newfoundland and Labrador. The least support was found for PACS reducing the length of patient stay in hospital. The post PACS physician survey found similar results, although the belief that PACS will reduce the length of patient stay decreased significantly from pre to post PACS implementation. With respect to perceived challenges pre PACS, not being able to view images at the patient's bedside, lack of system support, and poor image quality on the Web were noted most often by physicians. There was a significant decrease found from pre to post PACS with the perception that there was inadequate image quality on workstations.

The pre PACS survey found the benefits most often reported by radiologists were less time needed to review an exam, and the improvements in their reporting and consultation efficiency. A decrease in the number of face-to-face consultations with other physicians was found to be a negative result of PACS. With respect to perceived challenges, inadequate Web speed was reported most often by radiologists.

All radiology technologists responding to the pre and post PACS surveys agreed that report turn around times will improve with PACS, and that PACS will enhance patient care in rural Newfoundland and Labrador. The challenge reported most often by technologists post PACS was inadequate workstation speed.

Two benefit measures were found to have significantly different levels of agreement depending on previous experience with PACS. Physicians with previous experience with PACS were more likely to agree that their efficiency had improved, and that they were able to make better decisions regarding patient care. Looking at the perceived challenges of PACS, physicians with no previous experience with PACS generally felt they experienced inadequate Web speed more so than those with previous experience.

Twelve quantitative benefit indicators were proposed by Infoway, for which data would need to be obtained from administrative databases. These indicators were: 1) degree of filmlessness, 2) digitally stored exams, 3) number of unique clinician user accounts, 4) number of active users, 5) number of remote users, 6) unnecessary duplicate exams, 7) exams dictated per radiologist scheduled hours, 8) worked productivity %, 9) exam end to dictation end turn-around-time, 10) total turnaround times, 11) patient transfers, and 12) cost per exam. Of these 12 indicators, administrative data was only available for two: report turn-around times and the cost per case analysis.

In the Terrier Health Authority, the largest hospital (Hospital_A) experienced a significant increase in report TATs for all modalities. These increases were found to be the result of shortages in transcriptionists, and not related to PACS itself. Of note, five of the six smaller sites experienced a significant decrease in report TATs, mainly due to no longer having to transport exams for consultation via taxis. In the Mastiff Health Authority, the report TATs' significantly decreased for the majority of modalities following the implementation of PACS, even though this region also experienced challenges with maintaining appropriate levels of transcriptionists. However, the two main hospitals in the Mastiff Health

Authority were large enough to absorb the shortfalls in transcribing by increasing overtime and contracting with retired transcriptionists. The third site studied in the Mastiff Health Authority had a small volume of exams, but was still able to achieve a significant decrease in report TAT's given that, as with the Terrier Authority, exams no longer had to be transported for consultation via taxi.

Using basic accounting the cost per case analysis carried out in the Terrier Health Authority estimated that the adjusted cost per exam in the PACS environment was $11.8, compared to $9.5 in the film environment. Overall, the cost per case analysis estimated that it will cost an average of $2.65 more per exam in PACS than in film for the first six years of PACS operation. A second approach used constant payments (one a year for 10 years) and a constant interest rate (6%) and found the cost per exam was almost equal in both environments. The challenge in achieving a return on investment for PACS in the Terrier Authority was the high costs for PACS hardware, software and, in particular, the ongoing maintenance.

The total cost of ownership required to achieve a provincial PACS over the period 2005-2007 was estimated to be $23,637,711, of which the province would contribute $12,266,256 (54%), Infoway would provide $10,571,455 (46%), with the Centre for Health Information providing an additional $800,000 through in-kind contributions. The total costs for hardware and software was $19,723,527 (86.4%), with $3,114,184 (13.6%) allocated for professional services. Other jurisdictions considering a PACS implementation need to recognize the significant amount of in-house resources needed when undertaking such a large implementation.

Key informant interviews were held with 20 health professionals representing a broad range of administrative and clinical staff. The interviews found overwhelming support for PACS from all professional groups, across all benefit areas. However, the interviews did uncover some problem areas, in particular, physicians reported that training was inadequate, and that access to PACS outside the hospital was limited. From the administrative perspective, the implementation went extremely well, although there were issues raised regarding the Project Team's limited experience in large scale PACS implementations, which resulted in some short-term challenges specific to change management. No major concerns were raised by radiologists or technologists during the interviews.

6.2 Implications of Findings

6.2.1 Future Implementations of PACS

In Newfoundland and Labrador the provincial PACS implementation was completed in November 2007, with first implementations, or enhancements to existing installations, occurring over a 2-year period. While no further implementations are planned in the province, it is expected that enhancements to existing infrastructure, in particular the rural links to the provincial network, will continue so that improvements can be made to external access and Web speed. Within Canada, the entire funding envelope for PACS available through Canada Health Infoway ($340 million) has been allocated or committed, with no further funding expected from the federal government. While new implementations of PACS will continue in Canada, they most likely will not be able to avail of funding from the Canada Health Infoway EHR initiative.

6.2.2 Future Evaluation of PACS

In Newfoundland and Labrador there are no further evaluations of PACS planned or underway. Consideration for future evaluations should include the impact that PACS had on reducing both duplicate exams and patient transfers. Both of these subject areas were not possible to investigate in this current study using administrative data, and in spite of their importance from both a patient care and financial perspective, neither has received much attention in the literature. Another area of study that warrants attention is the impact that current voice recognition software will have on turn-around-times in the major hospitals being considered for this technology. While turn-around-times have for the most part improved relative to the film environment, the lack of transcriptionists across the province has limited this benefit. Such a study would be important in adding evidence to the debate on whether or not voice recognition is a major factor in reducing report TATs.

At the national level, Canada Health Infoway is in the planning stages of preparing a compilation of results from the major PACS evaluations funded by Infoway. These evaluations were undertaken in Nova Scotia (Survey), Ontario (Survey and Financial Analysis), British Columbia (Survey, Financial Analysis, and TAT) and Newfoundland and Labrador (Survey, TAT, Interviews, Financial Analysis, Administrative Data). While not confirmed, early indications are that the study will report on each evaluation separately, rather than carrying out a secondary analysis by combining each province's study data. It would be desirable that data from these evaluations be linked as much as possible.

6.3 Conclusion

The findings of this study provide convincing evidence that clinicians, administrators and support staff strongly support the creation of a provincial PACS in Newfoundland and Labrador. The implementation of the provincial PACS was successful largely due to: 1) a positive political and financial environment, and 2) the approach taken by the Centre for Health Information in engaging key stakeholders throughout the implementation process which built champions, and established a sense of ownership within the regional health authorities. The benefits of PACS, in particular immediate access to historical and current exams and reports from multiple access points 24/7, and site-to-site physician/radiologist consultations, were seen as key rationales for introducing the provincial PACS.

The realization of a provincial PACS has not come without its challenges. The main disadvantage from a clinical perspective is that PACS has resulted in a decrease in physician to radiologist consultations within a site, although this is offset somewhat by an increase in consultations between sites. From the administrative side, PACS was very costly to implement in the Terrier Health Authority, which resulted in PACS costing more per exam than film. While costs for PACS is not an issue today in Newfoundland and Labrador, given the financial contribution from Infoway, it could have serious implications in 5-6 years when the current PACS technology needs to be replaced and/or upgraded, and the regional authorities must do so within their own resources.

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Appendix A

Newfoundland and Labrador Acute Care Sites
By Number of Beds

Appendix A

Number of Beds by Acute Care Site
Newfoundland (Excluding Labrador)
As of December 2007

Site by Health Authority	Beds
Mastiff	**925**
Hospital_K	4
Hospital_L	9
Hospital_M	76
Hospital_N	20
Hospital_O	332
Hospital_H	86
Hospital_P	208
Hospital_I	94
Hospital_J	11
Hospital_Q	41
Hospital_R	42
Hospital_S	2
Spaniel	**254**
Hospital_T	90
Hospital_U	11
Hospital_V	4
Hospital_W	16
Hospital_X	8
Hospital_Y	4
Hospital_Z	2
Hospital_AA	119
Hospital_BB	6
Terrier	**266**
Hospital_C	20
Hospital_F	1
Hospital_A	186
Hospital_B	40
Hospital_D	13
Hospital_E	6

Appendix B

Survey Questionnaires Administered to Radiologists and Radiology Technologists/Technicians Pre and Post PACS Implementation

Appendix B-1

Pre PACS Opinion Survey
Radiologists/Technologists

Thank you for agreeing to complete this questionnaire. As noted in the cover letter, the purpose of this study is to determine the benefits of implementing/enhancing the Picture Archiving and Communications System in Newfoundland and Labrador. This survey looks at your current film environment (Sections I and II), your perceived benefits and potential challenges to PACS prior to implementation (Sections III and IV), and demographics (Section 5). Your responses are anonymous, no personal identifiers are attached to this questionnaire.

Section I: Current Use of Film

Please respond to statement 1 through 8 by circling one of the following responses:

1 Never **(N)**
2 Rarely
3 Sometimes
4 Frequently
5 Always **(A)**
6 Not Applicable (N/A)

How often you use film in the following ways:

	(N)				(A)	N/A
1) Clinical assessment	1	2	3	4	5	6
2) Clinical diagnosis	1	2	3	4	5	6
3) Clinical treatment	1	2	3	4	5	6
4) Professional education	1	2	3	4	5	6
5) Rounds	1	2	3	4	5	6
6) Patient education	1	2	3	4	5	6
7) Health services research	1	2	3	4	5	6
8) Other (specify) ____________	1	2	3	4	5	6

Section II: Current Environment with Respect to Locating Film/Reports

Please respond to statement 9 and 10 by circling one of the following responses:

1 Strongly Disagree **(D)**
2 Moderately Disagree
3 Moderately Agree
4 Strongly Agree **(A)**
5 Not Applicable (N/A)

To what extent you agree or disagree with statements 9 and 10:

	(D)			(A)	N/A
9) I can always find film when I need it	1	2	3	4	5
10) I can always find a report when I need it	1	2	3	4	5

11) What is the average time per day you spend looking for film? Minutes____ Hours _____ N/A

12) What is the average time per day you spend looking for reports? Minutes____ Hours _____ N/A

13) What is the average time per day you spend managing/handling films? Minutes____ Hours _____ N/A

14) How often is your clinical schedule delayed because of a delay in obtaining prior exams?

Never ❐ Rarely ❐ Sometimes ❐ Very Often ❐ Always ❐ N/A ❐

15) How satisfied are you with the amount of time it takes to retrieve or access each of the following?

	Very Dissatisfied	Dissatisfied	Satisfied	Very Satisfied	N/A
Film	❐	❐	❐	❐	❐
Reports	❐	❐	❐	❐	❐

16) How important are the following in managing patient care (e.g. rendering a diagnosis, treatment planning, etc.)?

	Not At All Important	Not Very Important	Somewhat Important	Very Important	N/A
Film	❐	❐	❐	❐	❐
Reports	❐	❐	❐	❐	❐

17) How often do you look at prior film and/or reports?

	Never	Rarely	Sometimes	Very Often	Always	N/A
Film	❐	❐	❐	❐	❐	❐
Reports	❐	❐	❐	❐	❐	❐

18) After how much time is a film no longer referred to in the patient care process?

< 3 Months ❐ 3-6 Months ❐ 6-12 Months ❐ 12-18 Months ❐ >18 Months ❐

Depends on Clinical Context ❐ N/A ❐

19) How many hospital sites do you work in? ____

20) Please estimate the number of hours per week you spend travelling between hospital sites
(If less than one hour, please write 0)

Hours ____ N/A

21) Where do you currently access film and/or reports? (Please check all that apply.)

Film	Reports
❐In medical imaging	❐In medical imaging
❐Private office	❐Private office
❐Home office	❐Home office

22) What do you access most frequently?:

Exams	❐
Reports	❐
Both	❐

Section III: Perceived Benefits of PACS Pre-Implementation

Please consider the current film-based environment when indicating the extent to which you agree or disagree with the following statements.

Please respond to statement 23 through 35 by circling one of the following responses:	
1	Strongly Disagree (D)
2	Moderately Disagree
3	Moderately Agree
4	Strongly Agree (A)
5	**Not Applicable**

	(D)			(A)	N/A
23) PAC will reduce the time I spend locating exams for review.	1	2	3	4	5
24) I will access prior exams more frequently with PACS than I did with film.	1	2	3	4	5
25) I believe report turnaround time will improve because of PACS (i.e. time to report dictated or time to preliminary report available).	1	2	3	4	5
26) I believe that PACS tools and functionality will improve the quality of my report.	1	2	3	4	5
27) PACS will improve the quality and number of patient management rounds that I participate in.	1	2	3	4	5
28) PACS will increase the number of face to face consultations I have with physicians and other radiologists.	1	2	3	4	5
29) PACS will increase the number of phone (or other) consultations I have with physicians and other radiologists.	1	2	3	4	5
30) PACS will reduce my professional travel time.	1	2	3	4	5
31) PACS will improve medical student/radiology resident teaching.	1	2	3	4	5
32) With the implementation of PACS, I will report remotely for sites to which I previously traveled.	1	2	3	4	5
33) With the implementation of PACS, I will report remotely for new sites.	1	2	3	4	5
34) PACS will improve my reporting and consultation efficiency	1	2	3	4	5
35) PACS will enhance patient care and service delivery in rural Newfoundland and Labrador	1	2	3	4	5

Section IV: Potential Challenges of PACS Pre-Implementation

In your opinion, what might be the potential challenges to using PACS? Please indicate the extent to which you agree or disagree with the following statements.

> Please respond to statement 36 through 47 by circling one of the following responses:
>
> 1 Strongly Disagree (D)
> 2 Moderately Disagree
> 3 Moderately Agree
> 4 Strongly Agree (A)
> **5 Not Applicable**

	(D)			(A)	N/A
36) PACS will produce inadequate image quality on the remote Web (e.g. from home).	1	2	3	4	
37) PACS will produce inadequate image quality on the workstation	1	2	3	4	
38) PACS will provide inadequate functionality on the remote Web	1	2	3	4	
39) PACS will produce inadequate functionality on the workstation	1	2	3	4	
40) I will have difficulty finding images in PACS when I need them.	1	2	3	4	
41) I will experience inadequate remote Web performance (speed)	1	2	3	4	
42) I will experience inadequate Workstation performance (speed)	1	2	3	4	
43) I will experience inadequate access to PACS viewing stations.	1	2	3	4	
44) I will have difficulty logging on to the system	1	2	3	4	
45) PACS downtime will be higher than acceptable.	1	2	3	4	
46) I will receive insufficient training in the new technology.	1	2	3	4	
47) I will experience a lack of availability of system support.	1	2	3	4	

Section V: Demographics

48) Please indicate your gender

- Male ❐
- Female ❐

49) Years in practice

- under 2 years ❐
- 2 to 5 ❐
- 6 to 10 ❐
- 11 to 15 ❐
- 16 to 20 ❐
- 21 to 25 ❐
- over 25 ❐

50) Have you had experience with PACS prior to this implementation project?

Yes ☐
No ☐

51) Please indicate your profession

Radiologist Physician ☐
Radiology Technologist ☐
Other (specify) ____________________

52) What hospital site do you normally work in?

General Hospital ☐
St. Clares ☐
Western Memorial ☐
Charles S. Curtis Memorial ☐
Other (Specify) ____________________

53) Comments

Please use this space to write any other comments you may have about the PACS system.

____

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Thank you for taking the time to complete this questionnaire!!!

Appendix B-2

Post PACS Opinion Survey
Radiologists/Technologists

Thank you for agreeing to complete this questionnaire. As noted in the cover letter, the purpose of this study is to determine the benefits of Picture Archiving and Communications Systems in Newfoundland. This survey looks at your current environment (Section I), your perceived benefits and potential challenges to using PACS (Sections II and III), and demographics (Section IV). Your responses are anonymous; no personal identifiers are attached to this questionnaire.

Section I: PACS Environment

1) Please indicate your profession

Radiologist Physician ☐
Radiology Technologist ☐
Radiology Technician ☐

Other (specify) ____________________________

2a) What Regional Health Authority do you normally work in?

Eastern Health Authority ☐
Central Health Authority ☐
Western Health Authority ☐

2b) What hospital do you normally work from?

____

3a) Have you had experience with PACS prior to this implementation project?

Yes ☐
No ☐

3b) How may years of PACS experience have you had? ______

4) Where do you access the PACS System? (Please check all that apply.)

☐ In medical imaging
☐ In clinics/units/patient care floors
☐ Private office
☐ Home

5) What do you access most frequently?:

☐ Exams
☐ Reports
☐ Both

Section II: Perceived Benefits of PACS

Please consider the current film-based environment when indicating the extent to which you agree or disagree with the following statements.

Please respond to statement 6 through 18 by circling one of the following responses:

1	Strongly Disagree (D)
2	Moderatcly Disagree
3	Moderately Agree
4	Strongly Agree (A)
5	**Not Applicable**

	(D)			**(A)**	N/A
6) PACS has reduced the time I spend locating exams for review.	1	2	3	4	5
7) I access prior exams more frequently with PACS than I did with film.	1	2	3	4	5
8) I believe that report turnaround time has improve because of PACS (i.e. time to report dictated or time to preliminary report available).	1	2	3	4	5
9) I believe that PACS tools and functionality improve the quality of my report.	1	2	3	4	5
10) PACS has improved the quality and number of patient management rounds that I participate in.	1	2	3	4	5
11) PACS has increased the number of face to face consultations I have with physicians and other radiologists.	1	2	3	4	5
12) PACS has increased the number of phone (or other) consultations I have with physicians and other radiologists.	1	2	3	4	5
13) PACS has reduced my professional travel time.	1	2	3	4	5
14) PACS has improved medical student/radiology resident teaching.	1	2	3	4	5
15) With the implementation of PACS, I report remotely for sites to which I previously traveled.	1	2	3	4	5
16) With the implementation of PACS, I report remotely for new sites.	1	2	3	4	5
17) PACS has improved my reporting and consultation efficiency	1	2	3	4	5
18) PACS has enhanced patient care and service delivery in rural Newfoundland and Labrador	1	2	3	4	5

Section III: Peceived Challenges of PACS

In your opinion, what might be the potential challenges to using PACS? Please indicate the extent to which you agree or disagree with the following statements.

Please respond to statement 19 through 31 by circling one of the following responses:

1	Strongly Disagree (D)
2	Moderately Disagree
3	Moderately Agree
4	Strongly Agree (A)
5	**Not Applicable**

	(D)			(A)	N/A
19) PACS produces inadequate image quality on the remote Web (e.g. from home).	1	2	3	4	
20) PACS produces inadequate image quality on the workstation	1	2	3	4	
21) PACS provides inadequate functionality on the remote Web	1	2	3	4	
22) PACS produces inadequate functionality on the workstation	1	2	3	4	
23) I have difficulty finding images in PACS when I need them.	1	2	3	4	
24) I experience inadequate remote Web performance (speed)	1	2	3	4	
25) I experience inadequate Workstation performance (speed)	1	2	3	4	
26) I experience inadequate access to PACS viewing stations.	1	2	3	4	
27) I have difficulty logging on to the system	1	2	3	4	
28) PACS downtime is higher than acceptable.	1	2	3	4	
29) I received insufficient training in the new technology.	1	2	3	4	
30) I experience a lack of availability of system support.	1	2	3	4	
31) The implementation/installation from film to PACS was well mamnaged	1	2	3	4	

Section V: Demographics

32) Please indicate your gender

- Male ❒
- Female ❒

33) Years in practice

- under 2 years ❒
- 2 to 5 ❒
- 6 to 10 ❒
- 11 to 15 ❒
- 16 to 20 ❒
- 21 to 25 ❒
- over 25 ❒

34) Comments

Please use this space to write any other comments you may have about the PACS system.

Thank you for taking the time to complete this questionnaire!!!

Appendix C

Survey Questionnaires Administered to Referring Physicians Pre and Post PACS Implementation

Appendix C-1

Pre PACS Opinion Survey
Referring Physicians

Thank you for agreeing to complete this questionnaire. As noted in the cover letter, the purpose of this study is to determine the benefits of implementing/enhancing the Picture Archiving and Communications System in Newfoundland and Labrador. This survey looks at the current film environment, as well as the perceived benefits and potential challenges to PACS prior to implementation. Your responses are anonymous, no personal identifiers are attached to this questionnaire.

Section I: Current Use of Film

Please respond to statement 1 through 8 by circling one of the following responses:

1	Never (N)
2	Rarely
3	Sometimes
4	Frequently
5	Always (A)
6	**Not Applicable (N/A)**

Please indicate how often you use film in the following ways:

	(N)				(A)	N/A
1) Clinical assessment	1	2	3	4	5	6
2) Clinical diagnosis	1	2	3	4	5	6
3) Clinical treatment	1	2	3	4	5	6
4) Professional education	1	2	3	4	5	6
5) Rounds	1	2	3	4	5	6
6) Patient education	1	2	3	4	5	6
7) Health services research	1	2	3	4	5	6
8) Other (specify)						

Seciotn II: Current Film Enviroment

Please respond to statement 9 and 10 by circling one of the following responses:

1	Strongly Disagree (D)
2	Moderately Disagree
3	Moderately Agree
4	Strongly Agree (A)
5	**Not Applicable (N/A)**

	(D)			(A)	N/A
9) I can always find film when I need it	1	2	3	4	5
10) I can always find a report when I need it	1	2	3	4	5

11) What is the average time per day you spend looking for film? Minutes____ Hours _____ N/A_____

12) What is the average time per day you spend looking for reports? Minutes____ Hours _____ N/A_____

13) What is the average time per day you spend managing/handling films? Minutes____ Hours _____ N/A _____

14) How often is your clinical schedule delayed because of a delay in obtaining prior exams?

❒ Never ❒ Rarely ❒ Sometimes ❒ Very Often ❒ Always ❒ N/A

15) How satisfied are you with the amount of time it takes to retrieve or access each of the following?

	Very Dissatisfied	Dissatisfied	Satisfied	Very Satisfied	N/A
Film	❒	❒	❒	❒	❒
Reports	❒	❒	❒	❒	❒

16) How important are the following in managing patient care (e.g. rendering a diagnosis, treatment planning, etc.)?

	Not At All Important	Not Very Important	Somewhat Important	Very Important	N/A
Film	❒	❒	❒	❒	❒
Reports	❒	❒	❒	❒	❒

17) How often do you look film or reports?

	Never	Rarely	Sometimes	Very Often	Always	N/A
Film	❒	❒	❒	❒	❒	❒
Reports	❒	❒	❒	❒	❒	❒

18) After how much time is a film no longer referred to in the patient care process?

❒< 3 Months ❒ 3-6 Months ❒ 6-12 Months ❒12-18 Months ❒>18 Months

❒ Depends on Clinical Context ❒ N/A

19) How many hospital sites do you work in? ____

20) Please estimate the number of hours per week you spend travelling between hospital sites.
(If less than one hour, please write 0)

______ Hours ______N/A

21) Where do you curently access film/reports? (Please check all that apply)

❒ In medical imaging
❒ On hospital site but not in medical imaging
❒ Private office/home

22) What do you access most frequently?

❒ Exams
❒ Reports
❒ Both

Section III: Perceived Benefits of PACS Pre-Implementation

In your opinion, what might be the benefit in using PACS? Please indicate the extent to which you agree or disagree with the following statements.

Please respond to statement 23 through 32 by circling one of the following responses:

1	Strongly Disagree (D)
2	Moderately Disagree
3	Moderately Agree
4	Strongly Agree (A)
5	**Not Applicable (N/A)**

	(D)			(A)	N/A
23) PACS will reduce the time I must wait to review an exam (images).	1	2	3	4	5
24) I will access prior exams more frequently with PACS than I did with film.	1	2	3	4	5
25) I believe that report turnaround time will improve because of PACS (i.e. time to report dictated or time to preliminary report available).	1	2	3	4	5
26) I believe that PACS tools and functionality will improve the quality of the report.	1	2	3	4	5
27) PACS will facilitated consultation between myself, other clinicians and/or radiologists at other health care locations.	1	2	3	4	5
28) My efficiency will improve because of PACS.	1	2	3	4	5
29) PACS will improve my ability to make decisions regarding patient care.	1	2	3	4	5
30) PACS will lead to a reduction in my patients' length of stay in hospital.	1	2	3	4	5
31) PACS will reduce the number of patient transfers between facilities due to the ability to share images and consult remotely.	1	2	3	4	5
32) PACS will reduce the number of exams reordered because the exams are not available (lost or located elsewhere) when I need them.	1	2	3	4	5

Section IV: Perceived Challenges of PACS

In your opinion, what might be the potential challenges to using PACS? Please indicate the extent to which you agree or disagree with the following statements.

Please respond to statement 33 through 43 by circling one of the following responses:

1	Strongly Disagree (D)
2	Moderately Disagree
3	Moderately Agree
4	Strongly Agree (A)
5	**Not Applicable (N/A)**

	(D)			(A)	N/A
33) PACS will produce inadequate image quality on the Web (e.g. from home).	1	2	3	4	5

	(D)			(A)	N/A
34) PACS will produce inadequate image quality on the workstation.	1	2	3	4	5
35) I will have difficulty finding images in PACS when I need them.	1	2	3	4	5
36) I will experience inadequate Web performance (speed).	1	2	3	4	5
37) I will experience inadequate workstation performance (speed).	1	2	3	4	5
38) I will have inadequate access to PACS viewing stations (PCs with Web or Workstations).	1	2	3	4	5
39) I will have difficulty logging on to the system.	1	2	3	4	5
40) PACS downtime will be higher than acceptable.	1	2	3	4	5
41) I will receive insufficient training in the new technology.	1	2	3	4	5
42) I will be unable to view images at the patient's beside.	1	2	3	4	5
43) I will experience a lack of availability of system support.	1	2	3	4	5

Section V: Demographics

44) Please indicate your gender

- ☐ Male
- ☐ Female

45) Years in practice

- ☐ under 2 years
- ☐ 2 to 5
- ☐ 6 to 10
- ☐ 11 to 15
- ☐ 16 to 20
- ☐ 21 to 25
- ☐ over 25

46) Have you had experience with PACS prior to this implementation project?

- ☐ Yes
- ☐ No

47) Please indicate your profession

- ☐ Non-Radiologist Physician
- ☐ Radiologist Physician
- ☐ Radiology Technologist
- ☐ Other (specify) ______________________________

48) What hospital site do you normally work in?

____

Thank you for taking the time to complete this questionnaire!

Appendix C-2

Post PACS Opinion Survey
Referring Physicians

Thank you for agreeing to complete this questionnaire. As noted in the cover letter, the purpose of this study is to determine the benefits of Picture Archiving and Communications Systems in Newfoundland and Labrador. This survey looks at your current environment (Sections I), your perceived benefits and potential challenges to using PACS (Sections II and III), and demographics (Section IV). Your responses are anonymous; no personal identifiers are attached to this questionnaire.

Section I: PACS Environment

1a) What Regional Health Authority do you normally work in?

- Eastern Health Authority ❒
- Central Health Authority ❒
- Western Health Authority ❒
- Labrador/Grenfell Health Authority ❒

1b) What hospital do you normally work from?

____

2a) Have you had experience with PACS prior to this implementation project?

- Yes ❒
- No ❒

2b) How may years of PACS experience have you had? ______

3) Where do you access the PACS System? (Please check all that apply.)

- ❒ In medical imaging
- ❒ In Clinics/Units/Patient Care Floors
- ❒ Private office
- ❒ Home

4) What do you access most frequently?:

- ❒ Exams
- ❒ Reports
- ❒ Both

5) Please indicate your speciality

Cardiology	❒	Family Practitioner /General Practitioner	❒
Internal Medicine	❒	Neurology	❒
Obstetrics/Gynecology	❒	Orthopedics	❒
Pediatrics	❒	Cardiac Surgery	❒
Thoracic Surgery	❒	Gastroenterology	❒
Emergency Medicine	❒	Neurosurgery	❒
Nephrology	❒	Orthopaedic Surgery	❒
Oncology	❒	Vascular Surgery	❒
Surgery	❒	Other, please specify ______________	

Section II: Perceived Benefits of PACS

In your opinion, what are the benefits in having PACS? Please indicate the extent to which you agree or disagree with the following statements.

Please respond to statement 6 through 16 by circling one of the following responses:

1	Strongly Disagree **(D)**
2	Moderately Disagree
3	Moderately Agree
4	Strongly Agree **(A)**
5	**Not Applicable (N/A)**

	(D)			**(A)**	**N/A**
6) PACS has reduced the time I must wait to review an exam (images).	1	2	3	4	5
7) I access exams more frequently with PACS than I do with film.	1	2	3	4	5
8) I believe that report turnaround time has improved with the implementation of PACS.	1	2	3	4	5
9) I believe that PACS tools and functionality improve the quality of the report.	1	2	3	4	5
10) PACS has facilitated consultation between myself, other clinicians and/or radiologists at other health care locations	1	2	3	4	5
11) My efficiency has improved because of PACS.	1	2	3	4	5
12) PACS has improved my ability to make decisions regarding patient care.	1	2	3	4	5
13) PACS has led to a reduction in my patients' length of stay in hospital.	1	2	3	4	5
14) PACS has reduced the number of patient transfers between facilities due to the ability to share images and consult remotely.	1	2	3	4	5
15) PACS has reduced the number of exams reordered because the exams were not available (lost or located elsewhere) when I need them.	1	2	3	4	5
16) PACS has enhanced patient care and service delivery in rural Newfoundland and Labrador	1	2	3	4	5

Section III: Potential Challenges of PACS

In your opinion, what are the challenges to using PACS? Please indicate the extent to which you agree or disagree with the following statements.

Please respond to statement 17 through 28 by circling one of the following responses:

1	Strongly Disagree **(D)**
2	Moderately Disagree
3	Moderately Agree
4	Strongly Agree **(A)**
5	**Not Applicable (N/A)**

	(D)			**(A)**	N/A
17) PACS produces inadequate image quality on the Web (e.g. from home)	1	2	3	4	5
18) PACS produces inadequate image quality on the hospital workstation	1	2	3	4	5
19) I have difficulty finding images when needed	1	2	3	4	5
20) I experience inadequate Web performance (speed)	1	2	3	4	5
21) I experience inadequate workstation performance (speed)	1	2	3	4	5
22) I have inadequate access to PACS viewing stations (PCs with Web or Workstations).	1	2	3	4	5
23) I have difficulty logging on to the system.	1	2	3	4	5
24) PACS downtime is higher than acceptable.	1	2	3	4	5
25) I received insufficient training in the new technology	1	2	3	4	5
26) I am unable to view images at the patient's bedside.	1	2	3	4	5
27) I experience a lack of availability of system support	1	2	3	4	5
28) The implementation/installation from film to PACS was well mamnaged	1	2	3	4	5

Section IV: Demographics

29) Please indicate your gender

- Male ❐
- Female ❐

30) Years in practice

- under 2 years ❐
- 2 to 5 ❐
- 6 to 10 ❐
- 11 to 15 ❐
- 16 to 20 ❐
- 21 to 25 ❐
- over 25 ❐

31) Comments

Please use this space to write any other comments you may have about the PACS system.

Thank you for taking the time to complete this questionnaire!!!

Appendix D

Reference List for Literature Review in Support of Survey Questionnaires for Radiologists/Technologists and Referring Physicians

Appendix D

Rationale/Validation for Survey Questions
Literature Review

Table 1

Section I: Pre PACS Implementation
Physicians and Radiologists Current Use of Film

Question Text	Indicator Rationale	Source
Section I: Current Use of Film		
Clinical Assessment	To determine pre-PACS use of film in rendering a clinical assessment.	Worthy et al (2003); Wadley et al (2002); Naul and Sinclair (2001); Terrier (2000); Watkins (1999); Williams et al (1997); Reiner et al (1996); Leckie et al (1993); Horii et al (1991)
Clinical Diagnosis	To determine pre-PACS use of film in rendering a clinical diagnosis.	Worthy et al (2003); Naul and Sinclair (2001); Terrier (2000); Watkins (1999); Williams et al (1997); Reiner et al (1996); Leckie et al (1993); Horii et al (1991); Hilsenrath et al (1991); Bryan et al (1999); Hischorn et al (2001)
Clinical Treatment	To determine pre-PACS use of film in rendering clinical treatment.	Worthy et al (2003); Naul and Sinclair (2001); Terrier (2000); Watkins (1999); Williams et al (1997); Reiner et al (1996); Leckie et al (1993); Horii et al (1991);
Professional Education	To determine pre-PACS use of film in professional education.	Hirshorn (2002); Yoshihiro et al (2002); Jansen and Veatch (2000); Leckie et al (1993); Yamamoto (1991); Rosset et al 2002; Scalzi and Sostman (1998); Aaron et al (2006); Siegel and Reiner (2001)
Rounds	To determine pre-PACS use of film in rounds.	Naul and Sinclair (2001)
Patient Education	To determine pre-PACS use of film in patient education.	Naul and Sinclair (2001); Parasyn et al (1998)
Health Services Research	To determine pre-PACS use of film in health services research.	Leckie et al (1993); Andriole et al (2004)

Table 2
Section II: Pre PACS Implementation
Physicians and Radiologists Locating of Film/Reports

Question Text	Indicator Rationale	Source
Section II: Locating Films and Reports		
I can always find film when I need it?	To measure productivity with respect to finding film.	Worthy (2003); Hayt et al (2001); Jansen and Veatch (2000); Bryan et al 1999); Reiner et al (1996); Siegel (1996); Leckie et al (1993); Lou and Huang (1992)
I can always find a report when I need it?	To measure productivity with respect to finding reports.	Worthy (2003); Hayt et al (2001); Jansen and Veatch (2000); Bryan et al (1999); Reiner et al (1996); Siegel et al (1996); Leckie et al (1993); Lou and Huang (1992)
What is the average time per day you spend looking for film?	To measure productivity with respect to time finding film.	Worthy (2003); Jansen and Veatch (2000); Reiner (1996); Siegel et al (1996); Leckie et al (1993); Lou and Huang (1992)
What is the average time per day you spend looking for a report?	To measure productivity with respect to time finding a report.	Worthy (2003); Jansen and Veatch (2000); Siegel et al (1996); Leckie et al (1993); Lou and Huang (1992)
What is the average time per day you spend managing and handling films?	To measure productivity with respect to time spent managing and handling film.	Worthy (2003); Jansen and Veatch (2000); Siegel et al (1996); Leckie et al (1993); Lou and Huang (1992)
How often is your clinical schedule delayed because of a delay in obtaining prior exams?	To measure productivity with respect to scheduling patient care actvities.	Worthy (2003); Jansen and Veatch (2000); Reiner et al (1996, 2002); Siegel et al (1996); Leckie et al (1993); Lou and Huang (1992)
How satisfied are you with the amount of time it takes to retrieve/access film?	To measure user satisfaction with respect to accessing film.	Worthy (2003); Jansen and Veatch (2000); Reiner et al (1996); Leckie et al (1993); Lou and Huang (1992)
How important is film in managing patient care	To measure perceived value of film in managing patient care pre-PACS.	Kundel (1996); Wadley et al (2002); Naul and Sinclair (2001); Terrier (2000); Tabar (1999); Reiner et al (1996); Siegel et al (1996); Leckie et al (1993)
How important are reports in managing patient care	To measure perceived value of reports in managing patient care pre-PACS.	Kundel (1996); Wadley et al (2002); Naul and Sinclair (2001); Terrier (2000); Tabar (1999); Reiner et al (1996); Leckie et al (1993)
How often do you look film?	To measure the frequency of looking for film pre-PACS	Dywer (2005); Naul and Sinclair (2001); Tabar (1999); Siegel et al (1996); Leckie et al (1993)
How often do you look reports?	To measure the frequency of looking for reports pre-PACS.	Dywer (2005); Naul and Sinclair (2001); Tabar (1999); Siegel et al (1996); Leckie et al (1993)
After how much time is a film no longer referred to in the patient care process?	To measure access to historical film pre-PACS	Dywer (2005); Worthy et al (2003); Naul and Sinclair (2001); Terrier (2000); Williams et al (1997); Leckie et al (1993)
How many hospital sites do you work in?	To determine travel time required pre PACS	Liu et al (2004); Scalzi and Sostman (1998)
Please estimate the number of hours per	To determine travel time required pre PACS	Liu et al (2004); Scalzi and Sostman (1998)

week you spend traveling between hospital sites		
Where do you currently access film/reports?	To measure pre PACS access of reports/film off site	Wadley et al (2002); Naul and Sinclair (2001); Jansen and Veatch (2000); Yousem and Beauchamp (2000)
What do you access most frequently: exams, reports or both?	To measure pre and post PACS the frequency of access to reports/film off site	Dywer (2005); Naul and Sinclair (2001); Tabar (1999); Siegel (1995); Leckie et al (1993)

Table 3
Section III: Pre and Post PACS Implementation
Physician's Perceived Benefits

Question Text	Indicator Rationale	Source
Section III: Benefits of PACS Implementation		
PACS will/has reduce(d) the time I must wait to review an exam (images).	To measure the perceived benefit of PACS in reducing the time to review an exam pre-PACS and compare to the post-PACS environment	Chan et al (2002); Cox and Dawe (2002); Naul and Sinclair (2001); Bryan et al (1999); Terrier (2000); Williams (1997); Chan et al (2002); Leckie et al (1993); Hilsenrath et al (1991); Reiner et al (2001); Watkins (1999); Andriole (2002);
I will/have access(ed) exams more frequently with PACS than with film.	To measure the perceived benefit in PACS in increasing the frequency in accessing exams pre-PACS and compare to the post-PACS environment	Naul and Sinclair (2001); Tabar (1999); Leckie et al (1993)
I believe that report turnaround time will/has improve(d) with the implementation of PACS.	To measure the perceived benefit of PACS in reducing the time to prepare the report pre-PACS and compare to the post-PACS environment	Marquez and Stewart, 2005; Siegel and Reiner (2003); Chan et al (2002); Siegel and Reiner (2002); Reiner et al (2000); Terrier (2000); Bryan et al (1999); Williams et al (1997); Leckie et al (1993); Hilsenrath et al (1991); Siegel et al (1996); Bryan et al (1998); Nitrosi et al (2007); Lepanto et al (2006); Morgan et al (2007)
I believe that PACS tools and functionality will/has improve(d) the quality of the report	To measure the perceived benefits of PACS functionality pre-PACS and compare to the post-PACS environment	Naul and Sinclair (2001); Williams et al (1997); Reiner et al (1996); Hilsenrath et al (1991); Reiner et al (2003); Bick and Lenzen (1999)
PACS will/has facilitated consultation between myself, other clinicians and/or radiologists at other health care locations	To measure the perceived benefit of PACS in improving consultations pre-PACS and compare to the post-PACS environment	Hayt et al (2001); Naul and Sinclair (2001); Watkins et al (2000); Reiner et al (1996); Leckie et al (1993); Siegel et al (1996)
My efficiency will /has improve(d) because of	To measure the perceived benefit PACS in improving	Worthy et al (2003); Rumreich and Johnson (2003); Siegel et al (1996); Andriole et al (2002,

PACS.	efficiency pre-PACS and compare to the post-PACS environment	2004); Bedel and Zdanowicz (2004)
PACS will/has improve(d) my ability to make decisions regarding patient care.	To measure the perceived benefit PACS in improving decision making pre-PACS and compare to the post-PACS environment	Toby (2004); Naul and Sinclair (2001); Terrier (2000); Tabar (1999); Leckie et al (1993); Sacco et al (2002); Reiner et al (1996); Wadley et al (2002); Andriole et al (1996, 2004); Arenson et al (2000); Colin et al (1998); Nitrosi et al (2007)
PACS will/has lead to a reduction in my patients' length of stay in hospital.	To measure the perceived benefit PACS in reducing length of stay pre-PACS and compare to the post-PACS environment	Bryan (1999); Watkins (1999); Reiner et al (1996); Sacco et al (2002); Seigel et al (1996); Nitrosi et al (2007)
PACS will/has reduce(d) the number of patient transfers between facilities due to the ability to share images and consult remotely.	To measure the perceived benefit PACS in reducing patient transfers pre-PACS and compare to the post-PACS environment	Liu et al (2004); Naul and Sinclair (2001); Horii et al (1991)
PACS will reduce the number of exams reordered because the exams are not available (lost or located elsewhere)	To measure the perceived benefit PACS in reducing exam re-orders pre-PACS and compare to the post-PACS environment	Siegel and Reiner (2003); Bryan et al (1999); Reiner et al (2000); Leckie et al (1993); Siegel et al (1996); Stickland (2000)

Table 4
Section IV: Pre and Post PACS Implementation
Physician's Perceived Challenges

Question Text	Indicator Rationale	Source
Section IV: Challenges of PACS Pre/Post Implementation		
PACS will/has produce(d) inadequate image quality on the Web	To measure the perceived challenge with image quality on the web pre-PACS and compare to post-PACS environment	Pilling (2003); Cox and Dawe (2002); Naul and Sinclair (2001); Mullins et al (2001); Jansen and Veatch (2000); Bryan et al (1999); Watkins (1999); Ravin (1990)
PACS will/has produce(d) inadequate image quality on the workstation	To measure the perceived challenge with image quality on a workstation pre PACS and compare to post-PACS environment	Pilling (2003); Horrii and Nisenbaum (2002); Naul and Sinclair (2001); Inamura et al (2001); Jansen and Veatch (2000); Bryan et al (1999); Watkins (1999); Gay (2002); Leckie et al (1993); Ravin (1990)
I will/have difficulty finding images when needed	To measure the perceived challenge in finding images pre PACS and compare to post-PACS environment	Jansen and Veatch (2000); Bryan et al (1999); Leckie et al (1993)

I will/have experience(d) inadequate Web performance (speed)	To measure the perceived challenge with web performance pre PACS and compare to post-PACS environment	Kundel (2005); Watkins (1999)
I will/have experience (d) inadequate workstation performance (speed)	To measure the perceived challenge workstation performance pre PACS and compare to post-PACS environment	Kundel (2005); Watkins (1999)
I will/ have inadequate access to PACS viewing stations (PCs with Web or Workstations).	To measure the perceived challenge with access to viewing stations pre PACS and compare to post-PACS environment	Naul and Sinclair (2001); Jansen and Veatch (2000)
I will/have difficulty logging on to the system.	To measure the perceived challenge with logging on the system pre PACS and compare to post-PACS environment	Lou and Huang (1992)
PACS downtime will/has be(en) higher than acceptable	To measure the perceived challenge with system down-time pre PACS and compare to post-PACS environment	Naul and Sinclair (2001); Lou and Huang (1992)
I will/have receive(d) insufficient training in the new technology	To measure the perceived challenge with training in the new technology pre PACS and compare to post-PACS environment	Blado and Carr (2004); Redfern (2002); Maass et al (2001); Sack (2001); Strickland (2000); Watkins (1999); Protopapas et al (1996)
I will/have be(en) unable to view images at the patient's bedside.	To measure the perceived challenge with viewing images at the patient's bedside pre PACS and compare to post-PACS environment	Sterling et al (2003); Naul and Sincleair (2001)
I will/have experience(d) a lack of availability of system support	To measure the perceived challenge with IT support pre PACS and compare to post-PACS environment	Bedel and Zdanowicz (2004); Cox and Dawe (2002); Hasley (2002); Hayt and Alexander (2001)

Table 5
Section III: Pre and Post PACS Implementation
Radiologists Perceived Benefits

Question Text	Indicator Rationale	Source
Section III: Perceived Benefits		
PAC will reduce the time I spend locating exams for review?	To determine perceived time taken to access exams for review pre-PACS and compare to post-PACS environment.	Worthy et al (2003); Hayt et al (2001); Jansen and Veatch (2000); Bryan et al (1999); Reiner et al (1998); Leckie et al (1993); Lou and Huang (1992)
I will access prior exams more frequently with PACS than I did with film?	To compare perceived access to exams pre-PACS and compare to post-PACS environment.	Naul and Sinclair (2001); Tabar (1999); Leckie et al (1993)
I believe report turnaround time will improved because of PACS ?	To determine if perceived report turnaround increases from pre-PACS to post-PACS environment.	Marquez and Stewart (2005); Siegel and Reiner (2003); Chan et al (2002); Siegel and Reiner (2002); Redfern et al (2000); Reiner et al (2000); Terrier (2000); Bryan et al (1999); Williams et al (1997); Andriole et al (1996); Leckie et al (1993); Hilsenrath et al (1991)
I believe that PACS tools and functionality will improve the quality of my report.	To compare perceived value of PACS functionality pre-PACS and compare to value perceived post-PACS environment.	Reiner et al (2003); Naul and Sinclair (2001); Williams et al (1997); Hilsenrath et al (1991); Morgan et al (2006)
PACS will improve the quality and number of patient management rounds that I participate in?	To compare perceived value of PACS in rounds participation pre-PACS and compare to value perceived post-PACS environment.	Arenson et al (2000); Strickland (2000)
PACS will increase the number of face to face consultations I have with physicians and other radiologists?	To compare perceived value of PACS in facilitating face-to-face physician consultations pre-PACS and compare to value perceived post-PACS environment.	Naul and Sinclair (2001); Hayt et al (2001); Watkins et al (2000); Leckie et al (1993)
PACS will increase the number of phone (or other) consultations I have with physicians and other radiologists?	To compare perceived value of PACS in facilitating physician phone (or other) consultations pre-PACS and compare to value perceived post-PACS environment.	Naul and Sinclair (2001); Hayt et al (2001); Watkins et al (2000); Leckie et al (1993)
PACS will reduce my professional travel time?	To compare perceived value of PACS in reducing professional travel time pre-PACS and compare to value perceived post-PACS environment.	Raman et al (2004); Tabar (1999)
PACS will improve medical student/radiology resident teaching?	To compare perceived value of PACS in resident teaching pre-PACS and compare to value perceived post-PACS environment.	Rossett et al (2002); Mullins et al (2001)
With the implementation of	To compare perceived value of	Scalza and Sostman (1998)

PACS, I will report remotely for sites to which I previously traveled?	PACS in supporting remote reporting pre-PACS and compare to value perceived post-PACS environment.	
With the implementation of PACS, I will report remotely for new sites?	To compare perceived value of PACS in supporting remote reporting pre-PACS and compare to value perceived post-PACS environment.	Scalza and Sostman (1998)
PACS will improve my reporting and consultation efficiency?	To compare perceived value of PACS in improving reporting and consultation efficiency pre-PACS and compare to value perceived post-PACS environment.	Tobey (2004); Siegel and Reiner (2003)

Table 6
Section IV: Pre and Post PACS Implementation
Radiologists Perceived Challenges

Question Text	Indicator Rationale	Source
Section IV: Perceived Challenges		
PACS will produce inadequate image quality on the Web?	To measure the perceived challenge with image quality on the web pre-PACS and compare to post-PACS environment	Pilling (2003); Cox and Dawe (2002); Naul and Sinclair (2001); Mulllins et al (2001); Jansen and Veatch (2000); Bryan et al (1999); Watkins (1999); Ravin (1990);
PACS will produce inadequate image quality on the workstation?	To measure the perceived challenge with image quality on a workstation pre PACS and compare to post-PACS environment	Pilling (2003); Mullins et al (2001); Naul and Sinclair (2001); Inamura et al (2001); Jansen and Veatch (2000); Siegel et al (2000); Yousem (2000); Bryan et al (1999); Watkins (1999); Gay (2002); Andriole et al (1996); Katto et al (1995); Horii et al (1994); Leckie et al (1993); Ravin (1990);
PACS will provide inadequate functionality on the remote Web?	To measure the perceived challenge with PACS functionality on the Web pre PACS and compare to post-PACS environment	Parasyn et al (1998)
PACS will produce inadequate functionality on the workstation?	To measure the perceived challenge with PACS functionality on a workstation pre PACS and compare to post-PACS environment	Parasyn et al (1998)
I will have difficulty finding images in PACS when I need them?	To measure the perceived challenge in finding images pre PACS and compare to post-PACS environment	Jansen and Veatch (2000); Bryan et al (1999); Leckie et al (1993);

I will experience inadequate remote Web performance (speed)?	To measure the perceived challenge with web performance pre PACS and compare to post-PACS environment	Kundel (2005); Watkins (1999);
I will experience inadequate Workstation performance (speed)?	To measure the perceived challenge workstation performance pre PACS and compare to post-PACS environment	Kundel (2005); Erberich et al (2003); Watkins (1999)
I will have inadequate access to PACS viewing stations (PCs with Web or Workstations)?	To measure the perceived challenge with access to viewing stations pre PACS and compare to post-PACS environment	Naul and Sinclair (2001); Jansen Veatch (2000)
I will have difficulty logging on to the System?	To measure the perceived challenge with logging on the system pre PACS and compare to post-PACS environment	Lou and Huang (1992)
PACS downtime will be higher than acceptable?	To measure the perceived challenge with system down-time pre PACS and compare to post-PACS environment	Naul and Sinclair (2001); Huang et al (1996); Lou and Huang (1992);
I will receive insufficient training in the new technology?	To measure the perceived challenge with training in the new technology pre PACS and compare to post-PACS environment	Blado and Carr (2004); Redfern et al (2002); Reiner et al (2002); Swaton (2002); Maass et al (2001); Sack (2001); Strickland (2000); Watkins (1999); Protopapas et al (1996);
I will receive a lack of availability of system support.	To measure the perceived challenge with IT support pre PACS and compare to post-PACS environment	Bedel and Zdanowicz (2004); Cox and Dawe (2002); Hayt and Alexander (2001); Huang et al (1996)

Appendix E

Key Informant Interview Scripts

Appendix E-1

Key Informant Interview Scripts
Project Managers/DI/IT Directors/PACS Administrators

Study I.D. _____________ Date: ___________

---

1) What do you feel are the major benefits resulting from the implementation of Picture Archiving and Communications Systems (PACS)?

2) What limitations or gaps, if any, exist with respect to the PACS implementation?

3) Have there been any unintended consequences, positive or negative, as a result of the implementation of PACS?

4) What aspects of implementation went well?

5) What aspects of the implementation were challenging, or could have been improved?

6) What change management issues, if any, has resulted from the implementation of PACS and how are they being addressed? In particular,

    a) What support structures were in place during implementation? (i.e. leadership and funding)
    b) What privacy protocols have been developed or adopted regarding the collection, storage and exchange of electronic patient/client information? (i.e. policies an standards)
    c) What back-up procedures/recovery plans are in place?

7) Are there any resource (financial, personnel, etc.) efficiencies or inefficiencies resulting from the PACS implementation?

8) Briefly describe the approach taken to the training of staff to use PACS. How well did this approach work?

9) What take away messages or lessons learned would you consider important for other sites undertaking an implementation of PACS?

10) Do you have any other comments or feedback that you would like to add?

Appendix E-2

Key Informant Interview Scripts
Referring Physicians/Radiologists/Radiology Technologists

Study I.D. ______________ Date: ____________

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1) What do you feel are the major benefits resulting from the implementation of Picture Archiving and Communications Systems (PACS)?

2) What limitations or gaps, if any, exist with respect to the PACS implementation?

3) Have there been any unintended consequences, positive or negative, as a result of the implementation of PACS?

4) What aspects of implementation went well?

5) What aspects of the implementation were challenging, or could have been improved?

6) Briefly describe the approach taken to the training of staff to use PACS. How well did this approach work?

7) What take away messages or lessons learned would you consider important for other sites undertaking an implementation of PACS?

8) Do you have any other comments or feedback that you would like to add?

Appendix F

Ethics Approval Letters

Memorial
University of Newfoundland

Human Investigation Committee
Research and Graduate Studies
Faculty of Medicine
The Health Sciences Centre

February 21, 2007

Reference #07.31

Dr. D. Neville
c/o Mr. D. MacDonald
Newfoundland & Labrador Centre for
Health Information
1 Crosbie Place
St. John's, NL

Dear Dr. Neville:

At the meeting held on **February 15, 2007,** your application entitled "**Evaluating the Implementation of Picture Archiving and Communication Systems in Newfoundland and Labrador: Phase III Post-implementation Key-Informant Interviews**" was reviewed by the Human Investigation Committee. The Committee granted ***full board approval*** of the research study, as submitted.

Full approval has been granted for one year. You will be contacted to complete the annual update form approximately 8 weeks before the approval will lapse on **February 15, 2008**. It is your responsibility to ensure that the renewal form is forwarded to the HIC office not less than 30 days prior to the renewal date for review and approval to continue the study. The annual renewal form can be downloaded from the HIC website
http://www.med.mun.ca/hic/downloads/Annual%20Update%20Form.doc.

Modifications of the protocol/consent are not permitted without prior approval from the Human Investigation Committee. Implementing changes in the protocol/consent without HIC approval may result in the approval of your research study being revoked, necessitating cessation of all related research activity. Request for modification to the protocol/consent must be outlined on an amendment form (available on the HIC website) and submitted to the HIC for review.

For a hospital-based study, it is your responsibility to seek the necessary approval from the Health Care Corporation of St. John's and/or other hospital boards as appropriate.

This Research Ethics Board (the HIC) has reviewed and approved the trial which is to be conducted by you as the qualified investigator named above at the specified trial site. This approval and the views of this Research Ethics Board have been documented in writing. In addition, please be advised that the Human Investigation Committee currently operates according to the Good Clinical Practice Guidelines, the Tri-Council Policy Statement and applicable laws and regulations.

Notwithstanding the approval of the HIC, the primary responsibility for the ethical conduct of the investigation remains with you.

We wish you every success with your study.

Sincerely,

JHarnett

John D. Harnett, MD, FRCPC Co-Chair Human Investigation Committee	Richard S. Neuman, PhD Co-Chair Human Investigation Committee

JDH;RSN\jglc

C Dr. C. Loomis, Vice-President (Research), MUN
Mr. W. Miller, Director of Planning & Research, HCCSJ

Memorial
University of Newfoundland

Human Investigation Committee
Research and Graduate Studies
Faculty of Medicine
The Health Sciences Centre

December 1, 2006

Reference #06.243

Dr. Doreen Neville
e-Health Research Unit
Faculty of Medicine

Dear Dr. Neville:

Your application entitled "**Evaluating the implementation of picture archiving and communication systems in Newfoundland and Labrador: Phase II post-implementation survey**" was reviewed by a Sub-Committee of the Human Investigation Committee and full approval was granted.

This will be reported to the full Human Investigation Committee, for their information, at the meeting scheduled for **December 7, 2006**.

Full approval has been granted for one year. You will be contacted to complete the annual form update approximately 8 weeks before the approval will lapse on **November 30, 2007**. It is your responsibility to ensure that the renewal form is forwarded to the HIC office not less than 30 days prior to the renewal date for review and approval to continue the study. The annual renewal form can be downloaded from the HIC website http://www.med.mun.ca/hic/downloads/Annual%20Update%20Form.doc.

For a hospital-based study, it is **your responsibility to seek the necessary approval from the Health Care Corporation of St. John's and/or other hospital boards as appropriate**.

This Research Ethics Board (the HIC) has reviewed and approved the application for the study which is to be conducted by you as the qualified investigator named above at the specified study site. This approval and the views of this Research Ethics Board have been documented in writing. In addition, please be advised that the Human Investigation Committee currently operates according to the Tri-Council Policy Statement and applicable laws and regulations.

Notwithstanding the approval of the HIC, the primary responsibility for the ethical conduct of the investigation remains with you.

We wish you success with your study.

Sincerely,

John D. Harnett, MD, FRCPC
Co-Chair
Human Investigation Committee

Richard S. Neuman, PhD
Co-Chair
Human Investigation Committee

JDH;RSN\jd

C Dr. C. Loomis, Vice-President (Research), MUN
Mr. W. Miller, Director of Planning & Research, HCCSJ

Memorial
University of Newfoundland

Human Investigation Committee
Research and Graduate Studies
Faculty of Medicine
The Health Sciences Centre

November 8, 2005

Reference #05.206

Dr. Doreen Neville
Community Health
Faculty of Medicine

Dear Dr. Neville:

This will acknowledge your correspondence dated November 7, 2005, wherein you clarify issues and provide a copy of the budget, revised cover letter, & surveys, for your research study entitled "**Evaluating the implementation of picture archiving and communication systems in Newfoundland and Labrador**".

At the meeting held on **November 3, 2005**, the initial review date of this study, the Human Investigation Committee (HIC) agreed that the response could be reviewed by the Co-Chairs and, if found acceptable, full approval of the study be granted.

The Co-Chairs of the HIC reviewed your correspondence, approved the revised cover letter, & surveys and under the direction of the Committee, granted ***full approval*** of your research study. This will be reported to the full Human Investigation Committee, for their information at the meeting scheduled for **November 10, 2005**.

Full approval has been granted for one year. You will be contacted for annual update before **November 3, 2006**.

Modifications of the protocol/consent are not permitted without prior approval from the Human Investigation Committee. Implementing changes in the protocol/consent without HIC approval may result in the approval of your research study being revoked, necessitating cessation of all related research activity. Request for modification to the protocol/consent must be outlined on an amendment form (available on the HIC website) and submitted to the HIC for review.

For a hospital-based study, it is your responsibility to seek the necessary approval from the Health Care Corporation of St. John's and/or other hospital boards as appropriate.

This Research Ethics Board (the HIC) has reviewed and approved the application and consent form for the study which is to be conducted by you as the qualified investigator named above at the specified study site. This approval and the views of this Research Ethics Board have been documented in writing. In addition, please be advised that the Human Investigation Committee currently operates according to the Tri-Council Policy Statement and applicable laws and regulations.

Notwithstanding the approval of the HIC, the primary responsibility for the ethical conduct of the investigation remains with you.

We wish you every success with your study.

Sincerely,

John D. Harnett, MD, FRCPC
Co-Chair
Human Investigation Committee

Richard S. Neuman, PhD
Co-Chair
Human Investigation Committee

JDH;RSN\jjm

C Dr. C. Loomis, Vice-President (Research), MUN
Mr. W. Miller, Director of Planning & Research, HCCSJ

Memorial
University of Newfoundland

Human Investigation Committee
Research and Graduate Studies
Faculty of Medicine
The Health Sciences Centre

June 29, 2005

Reference #05.146

Dr. Doreen Neville
Community Health

Dear Dr. Neville:

Your application entitled "**Evaluating the Implementation of Picture Archiving and Communications System (PACS in Newfoundland and Labrador**" was reviewed by a Sub-Committee of the Human Investigation Committee and full **approval** was granted.

This will be reported to the full Human Investigation Committee, for their information, at the meeting scheduled for **July 7, 2005**.

Full approval has been granted for one year. You will be contacted for annual update before **June 29, 2006**.

For a hospital-based study, it is **your responsibility to seek the necessary approval from the Health Care Corporation of St. John's and/or other hospital boards as appropriate**.

This Research Ethics Board (the HIC) has reviewed and approved the application for the study which is to be conducted by you as the qualified investigator named above at the specified study site. This approval and the views of this Research Ethics Board have been documented in writing. In addition, please be advised that the Human Investigation Committee currently operates according to the Tri-Council Policy Statement and applicable laws and regulations.

Notwithstanding the approval of the HIC, the primary responsibility for the ethical conduct of the investigation remains with you.

We wish you success with your study.

Sincerely,

John D. Harnett, MD, FRCPC
Co-Chair
Human Investigation Committee

Richard S. Neuman, PhD
Co-Chair
Human Investigation Committee

JDH;RSN\jd

C Dr. C. Loomis, Vice-President (Research), MUN
Mr. W. Miller, Director of Planning & Research, HCCSJ

Appendix G

Key Informant Interview Request

1. Initial Contact E-mail Script
2. Follow-up Telephone Script Seeking Interview
3. Telephone Script Initiating Telephone Interview

Appendix G-1

Key Informant Interview Scripts
Initial E-Mail Script to Seek Interview

Dear __________________:

As you are aware, the Eastern Health Authority has been chosen for inclusion in a study to evaluate the impact of the implementation of Picture Archiving and Communication Systems in Newfoundland and Labrador.

Based on findings from the evaluation framework workshop held on September 8th, 2005 and consultations with Canada Health Infoway, three key research questions have been identified to address in the evaluation:

1. **What were the costs of implementing the PACS system and how do they compare to projected costs?**

2. **What are the benefits of the system and how to they compare to anticipated benefits?**
    a) Was the anticipated utilization/adoption of PACS achieved?
    b) Was there a reduction in unnecessary duplicate exams?
    c) Did productivity improve for both radiologists and technologists?
    d) Did turnaround time for reports improve?
    e) What was the impact on patient transfers between sites (i.e., ability to share mages and consult remotely)?
    f) What degree of access occurs in rural verses urban areas?

3. **What are the lessons learned for other jurisdictions engaging in similar initiatives?**

<u>**Description of Study Procedures**</u>

The complete study encompasses of a number of data collection strategies including surveys, interviews, administrative data and documentation review. At this time, we are seeking consent from key individuals to participate in a telephone interview. You will be contacted by the research analyst working on the study to ask for your participation in the study. With your consent, an interview time will be arranged. The interview will be conducted by telephone and will take approximately 45 minutes complete. The interview will be conducted by Mr. Don MacDonald, co-investigator on the study, with one other member of the study team present to document responses.

Please read the attached document which explains the study procedures in more detail.

Questions:

If you have any questions about taking part in this research, you can meet with, or contact, the Principal Investigator who is in charge of this study at the Faculty of Medicine, Memorial University of Newfoundland. That person is:

Dr. Doreen Neville   Phone: 737-3971   e-mail: DNeville@mun.ca.

Thank you very much for taking the time to inform yourself about this study.

Doreen Neville
Don MacDonald

Appendix G-2

Key Informant Interview Scripts
Follow-Up telephone Script to Seek Interview

Hello Mr. /Ms. _______________

This is Don MacDonald calling. I am working with Dr. Doreen Neville on a study in which we are evaluating the implementation of the Picture Archiving and Communication System (PACS) in Newfoundland and Labrador.

Approximately one week ago, you were sent a letter, via email, that describes the study as well as a document that outlines exactly what your participation in the study would entail. As you would have read in those documents, participation in the study is voluntary and confidentiality of all information is ensured.

I am calling now to ask for your participation in the study. This will involve participating in a telephone interview in which you will be asked a series of questions regarding the structure of the primary health care initiative with which you are involved with and the current technical environment. Are you willing to volunteer approximately 45 minutes of your time to participate in the study?

(If the individual agrees to participate) Shall we go ahead and schedule a time for the interview?

Scheduled interview date/time: ____________________________

Thank you very much Mr./Ms. ____________________________. I will contact you on *(interview date/time)* at which time the interview will take place.

I look forward to speaking with you again.

Appendix G-3

Key Informant Interview Scripts
Follow-up Telephone Script to Initiate Interview

Hello Mr. /Ms. _______________

This is Don MacDonald calling. As _____________ indicated I would, when he/she spoke with you previously, I am calling now to ask you a few questions regarding your perceptions concerning the implementation of Picture Archiving and Communications Systems (PACS) in your site.

Before we begin, I want to let you know that _________________ *(one other co-investigator)* is also present and that both of us will be taking notes during the interview.

Do you have any questions before we begin?

(see interview guides for questions to be asked)

(when interview is finished)

Thank you very much Mr./Ms. ____________________________. Your participation and time is very much appreciated.

Appendix H

Key Informant Interview: Elements of Consent Document

Appendix H

Key Informant Interview Scripts
Elements of Consent Document

Title: Evaluating the Implementation of Picture Archiving and Communication Systems in Newfoundland and Labrador: Phase III Post Implementation Interviews

Principal Investigator: Dr. Doreen Neville

Sponsors: Canada Health Infoway

You have been asked to take part in a research study. It is up to you to decide whether to be in the study or not. Before you decide, you need to understand what the study is for, what risks you might take and what benefits you might receive. This consent form explains the study.

The researchers will:

- Discuss the study with you
- Answer your questions
- Keep confidential any information which could identify you personally
- Be available during the study to deal with problems and answer questions

You may decide not to take part in, or leave the study, at any time.

Background

This study is designed to evaluate the implementation of the provincial Picture Archiving and Communication systems (PACS) funded in partnership with the Newfoundland and Labrador government and Canada Health Infoway.

Purpose

The purpose of the interview is to determine the perceptions concerning the implementation of Picture Archiving and Communication systems (PACS) among key individuals involved in this initiative.

Description of the Study Procedures

If you are willing to be interviewed, a research analyst will arrange a convenient time for a telephone interview.

Length of Time

The interview will take approximately 45 minutes to complete.

Possible Risks and Discomforts

There are no anticipated risks and discomforts associated with this study. However, participants will be asked to give freely of their time and will be asked to provide honest feedback.

Benefits

It is not known whether this study will benefit you personally.

Liability Statement

You will be contacted by the research analyst working on the study to ask for your participation in the study. If you verbally consent to participate in the study, this tells us that you understand the information about the research study. When you consent to participate, you do not give up your legal rights. Researchers or agencies involved in this research study still have their legal and professional responsibilities.

Confidentiality

By verbally agreeing to participate, you will be giving your permission for the assessment of information that you give during the interview. However, your name will not appear in any report or article published as a result of this study.

Questions

If you have any questions about taking part in this research, you can meet with, or contact, the Principal Investigator who is charge of this study at the Faculty of Medicine, Memorial University of Newfoundland. That person is:

Dr. Doreen Neville 709-737-3971 e-mail: DNeville@mun.ca.

Or you can talk to someone who is not involved with the study at all, but can advise you of your rights as a participant in a research study. This person can be reached through the:

Office of the Human Investigative Committee (HIC) at (709) 777-6974 (HIC@mun.ca)

Conflict of Interest Statement

Two co-investigators of this study are employees of the Newfoundland and Labrador Centre for Health Information and therefore may have a particular interest in the success of the study.

Appendix I

Key Informant Interview: Modified Phone Call Script
(No Physician E-Mail Address)

Appendix I

Key Informant Interview Scripts
Modified Telephone Script to Seek Interview
(No Physician E-Mail)

Hello Dr. ______________

This is Don MacDonald calling. I am working with Dr. Doreen Neville on a study in which we are evaluating the benefits of implementing Picture Archiving and Communication Systems (PACS) in Newfoundland and Labrador.

As a key informant in the provincial health system, I am calling to ask for your participation in the study. This will involve participating in a telephone interview in which you will be asked a series of questions regarding the implementation of PACS in the province. Participation in the study is voluntary and confidentiality of all information is ensured. Are you willing to volunteer approximately 45 minutes of your time to participate in the study?

(If the individual agrees to participate) Shall we go ahead and schedule a time for the interview?

Scheduled interview date/time: ___________________________

Thank you very much Dr. ___________________________. I look forward to speaking with you on *(interview date/time)*.

Appendix J

Pre Evaluation Workshop Findings

Appendix J

Findings of September 28, 2005
Pre PACS Benefit Evaluation Workshop

Study Design

The study is designed as a comparative (pre-post) case study. Three regions have been identified in the PACS evaluation that will either receive PACS, or will receive enhancements to an existing PACS. The former Health Care Corporation of St. John's - HCCSJ (now Eastern Integrated Health Authority), started site-wide implementation of PACS in the Summer of 2004. The former Western Health Care Corporation – WHCC (now Western Integrated Health Authority) has no PACS but have radiologists on staff, while the former Health Labrador Corporation – HLC (now Labrador-Grenfell Integrated Health Authority) has no PACS and no Radiologists. A fourth region, the Central Integrated Health Authority, will have their existing PACS enhanced as part of the 2005 initiative, however this region is beyond the scope of this evaluation.

Approach to Evaluation

The approach to this study will be both summative and formative and will follow the framework for the evaluation of electronic health records initiatives proposed by Neville, Gates, MacDonald et al (2004).

The framework outlines seven steps to follow in the evaluation: (1) identify key stakeholders; (2) orient stakeholders to the information systems initiative and reach agreement on why an evaluation is needed (accountability, performance enhancement, and/or knowledge development); (3) reach agreement on when to evaluate (pre, post, multiple data points etc); (4) reach agreement on what to evaluate (identify key research questions); (5) reach agreement on how to evaluate (methods); (6) Analyse and report findings; and (7) agree on recommendations and communicate them to key stakeholders.

Evaluation Framework Workshop

As the framework requires significant stakeholder involvement, key individuals in each of the three sites were invited to an Evaluation Framework Workshop where they were given 1) an orientation to the evaluation framework, 2) a presentation by GE Healthcare on a PACS evaluation completed in British Columbia and Ontario, and 3) an overview of the benefit areas already identified by Canada Health Infoway as core to the PACS evaluation (see Table 1). Workshop participants included representatives from GE Healthcare, Canada Health Infoway, each of the three regions in which PACS will be evaluated, the provincial PACS Project Manager, the Newfoundland and Labrador Centre for Health Information, and Dr. Doreen Neville, Principal Investigator on the study.

Following this orientation the attendees were divided into three smaller groups with instructions to: 1) validate the core set of PACS benefit indicators previous identified and 2) bring forward any additional key goals or research questions for the evaluation study. In formulating the questions, participants were asked to reflect on their current work processes, and to come up with additional questions which they feel would be important in measuring the benefits of PACS.

Following the morning workshop, which lasted one (1) hour, a summary session was held with all participants where each group presented their additional research questions that were identified based on the discussions generated. Some questions were common among the three groups; other questions were identified by only one group. A list of the unique questions coming out of the morning breakout sessions, categorized according to the three rationales for conducting an evaluation (i.e. Accountability, Performance Enhancement/Developmental and Knowledge Development), is found in Table 2.

In the afternoon, a second session took place where the same break out groups were asked to priorize the top 3-4 research questions identified in the morning session, and to identify potential indicator measures for each. The results of these deliberations is summarized in Table 3.

Key Research Questions

Based on workshop findings and questions identified in Canada Health Infoway's report *Electronic Diagnostic Imaging Indicators Reference Document*, a total of nine (9) key research questions have been identified to address in the evaluation:

1) Was the anticipated utilization/adoption of PACS achieved?
2) Was there a reduction in unnecessary duplicate exams?
3) Did productivity improve for both radiologists and technologists?
4) Did turnaround time for reports improve?
5) What was the impact on patient transfers between sites (i.e., ability to share images and consult remotely)?
6) What was the cost per case in a film-based environment compared to the cost per case in a PACS environment?
7) What were the total costs of implementing the PACS system and how do they compare to estimated costs pre-implementation?
8) What degree of access occurs in Rural verses Urban areas?
9) What were the lessons learned? (e.g., was the training for end-users adequate?)

Research questions #1 through #6 have previously been identified by Canada Health Infoway as core to the evaluation (Table 1).

Table 1
Core PACS Benefit Indicators and Reporting Period

Core Indicators (Infoway)	Collection	
	Pre-PACS	**Post-PACS**
Increased User Adoption		
1) Completed 30 Consecutive Days of 95% Filmless Operation		X
2) Total # of Digital Exams Stored Digitally/Total Exam Volume	X	X
3) Total # of Unique Clinician User Accounts/Total # of Clinicians		X
4) Total # of Unique Users Logged On/Total # of Unique User Accounts		X
5) Total # of Remote Users Logged On/Total # of Unique User Accounts		X
Improved Report Turnaround Time		
1) Exam End to Dictation End Turnaround Time[a]	X	X
2) Total Cycle Turnaround Time[b]	X	X
Increased Productivity		
1) Work Productivity % • Option A: (Service Recipient Workload/60 x 100) (Unit-Producing Personnel Worked and Purchased Hours) • Option B: (Exam Volume/FTE by Type (Technologist)) * 100 • Option C: (Total Resource Cost)/(Exam Volume) * 100	X	X
2) Exams Dictated Per Radiologist Scheduled Hours • Option A: # Exams Dictated/FTE Radiologist Scheduled Clinical Hours • Option B: PACS Opinion Survey	X	X
Decreased Utilization (Duplicate Tests)		
1) Unnecessary Duplicate Exams Ratio • Option A: (Total # of Repeat Exams due to unavailability)/(# Exams) • Option B: (PACS Opinion Survey)	X	X
Quality Indicators		
1) Patient Transfers • Option A: Count of Reasons for Transfers/Counts of Transfers • Option B: # of Transfers Post PACS/# Transfers Pre PACS	X	X
Financial Indicator		
8) Cost Per Case in Film Verses in PACS • Infoway Business Case Template or Sponsor Business Case	X	X

Building on the additional three research questions identified in the workshop, the following potential research questions and indicators presented in Table 2 have been identified for inclusion in the study:

Table 2
Additional Research Questions Identified

Area of focus	Indicators

What were the total costs of implementing the PACS system and how do they compare to estimated costs pre-implementation?	• Project scoping/needs assessment
	• Technology (hardware, software, networking, etc)
	    • capital
	    • maintenance/on-going
	• Personnel
	    • Training/user support (both initial and on-going)

What degree of access occurs in Rural verses Urban areas?	• Number of exams read remotely for Rural residents (Pre/Post) • Number reports sent to rural physicians (Pre/post) • Survey questions for rural urban physicians on value of PACS (pre/post)

Lessons Learned	• Characteristics of champions for technology
	• Key facilitators and barriers to success (e.g. team functioning at pre-implementation)
	• Change management requirements
	    • support during implementation
	    • fall back mechanisms
	    • privacy protocols
	• Unexpected consequences

Table 3 presents all research questions and indicators identified during the course of the workshop.

Table 3

Evaluation of Picture Archiving and Communications System Additional Research Questions – Workshop

Proposed Research Question	Accountability	Performance	Knowledge
Is there an improvement in patient care?		X	
What are the privacy issues with respect to the patient?			X
Are there less retakes of exams?	X	X	
Is there an impact on support staff/clerical staff?		X	
Is there a decrease in unrecorded images (impact)?	X	X	
Is there a correlation between implementing PACS and improved population health?		X	
Was the training for end-users adequate?		X	X
What access modes are being used/available?		X	
How does PACS improve efficiency for physicians?		X	
Does PACS impact training of residents?			X
Does PACS make things easier for monitoring work load for managers?			X
What is important to stakeholders?			X
Is there a reduction in paper?		X	
Are wait lists reduced?		X	
What degree of access occurs to other sites – potential for province-wide?		X	
Is there a difference between new install vs. upgrade?			X
Is there better budgeting control?	X		
Improved Patient safety outcomes?		X	
Improved Financial – budgeting control	X		
Is PACS sustainable?	X		
Does PACS improve the work environment for all employees?		X	
Improved report turnaround time – be able to break it down?		X	
What is the user satisfaction of PACS?			X
What is the difference between big bang vs. staged implementation?			X
Is there a best practices for governance?			X
Were there different approaches for building champions?			X
What was the level of clinician/radiologist support/adoption?		X	
Were physician/office ready for PACS?		X	
Who are all potential users?			X
Will there be ongoing monitoring/standards for quality control?		X	

Table 4
Potential Indicators for Research Questions Identified

Group	Priority Research Questions	Potential Indicators
#1	1. Patient Outcome/Safety	• Survival rates • TAT- exam treatment • Population health over long term (correlation to communities) • Accuracy of diagnosis
	2. Standards for Quality Control	• Presence of tools • Equipment arrival • Competency of users
	3. Training/Education	• Satisfaction • Competency levels following training • Plans for retraining • Improvements in staff morale • Help desk calls • Call backs to PACS
#2	1. Patient Outcome/Safety (i.e. blood clot)	None Given
	2. Sustainability	• Actual Cost verses Anticipated Cost (proposal/invoices) • Is the ongoing costs sustainable (ROI indicators)
	3. Patient/staff/clinician satisfaction	• Survey
#3	1. Training/Education	• Survey question on adequacy of training and ongoing support (amount of training) • Survey question about comfort with using PACS
	2. Security and Privacy	• Adherence to existing standards (including meditech protocols) • Survey question on satisfaction with levels of security/privacy (2 questions).
	3. Satisfaction (all users)	• Survey question based on net promoters score (i.e. would you refer the system to your colleague) • Survey question on satisfaction with training/support, ease of use, report turnaround times, efficiency, work processes.
	4. Quality Control	• Survey question on quality of end result (image) • Are there quality control practices in place • Adherence with benchmarks – waiting times • Measuring errors

Appendix K

Detailed Survey Response Rates by Region and Profession

Appendix K

Detailed Survey Response Rates by Region and Profession

Questionnaires were administered pre and/or post PACS implementation to physicians, radiologists, and radiology technologists employed in the three health authorities on the island potion of the province of Newfoundland and Labrador. Response rates by profession are reported below:

Pre PACS Survey: Physicians

All physicians in the Terrier Health Authority were administered a questionnaire 3-months pre PACS implementation.

The pre PACS physician questionnaire was mailed to all physicians in the Terrier Health Authority (n=120) on September 12th, 2005, three months prior to PACS being implemented. After three weeks a total of 30 physicians had returned completed questionnaires for an initial response rate of 25.0% (30/120). On October 3rd a second mail-out to all physicians (n=120) resulted in 8 additional physicians responding, for a 6.7% (8/120) response. On November 5, eight weeks after the initial mail-out, the final response rate for the Terrier Health Authority for the pre PACS physician survey was 31.7% (38/120) (Table 1).

Table 1
Pre PACS Physician Survey Response
Terrier Health Authority

Survey Group	Terrier Integrated Health Authority				Total
	1st Mail out Sept 12, 2005		2nd Mail out Oct 3, 2005		
	Mailed	Returned	Mailed	Returned	
Physicians	120	30 (25.0%)	120	8 (6.7%)	38 (31.7%)

Post PACS Survey: Physicians

All physicians in the Mastiff, Spaniel, and Terrier Health Authorities were administered a questionnaire post PACS implementation.

Mastiff Health Authority

The post PACS physician questionnaire was mailed to all physicians in the Mastiff Health Authority (n=659) on January 17th, 2007. After three weeks a total of 161 physicians had returned completed questionnaires for an initial response rate of 24.4% (161/659). On February 7th a second mail-out to all physicians (n=654) resulted in 80 additional physicians responding, for a 12.2% (80/654) response. Note that 5 questionnaires were returned with "address unknown" during the initial mail-out, and were excluded from the final total physician population. On March 16th, eight weeks after the initial mail-out, the final response rate for the Mastiff Health Authority for the post PACS physician survey was 36.9% (241/654) (Table 2).

Spaniel Health Authority

The post PACS physician questionnaire was mailed to all physicians in the Spaniel Health Authority (n=148) on January 17th, 2007. After three weeks a total of 36 physicians had returned completed questionnaires for an initial response rate of 24.3% (36/148). On February 7th a second mail-out to all physicians (n=145) resulted in 15 additional physicians responding, for a 10.3% (15/145) response. Note that 3 questionnaires were returned with "address unknown" during the initial mail-out, and were excluded from the final total physician population. On March 16th, eight weeks after the initial mail-out, the final response rate for the Spaniel Health Authority for the post PACS physician survey was 35.2% (51/145) (Table 2).

Terrier Health Authority

The post PACS physician questionnaire was mailed to all physicians in the Terrier Health Authority (n=125) on January 17th, 2007. After three weeks a total of 27 physicians had returned completed questionnaires for an initial response rate of 21.6% (27/125). On February 7th a second mail-out to all physicians (n=123) resulted in 16 additional physicians responding, for a 13.0% (8/120) response. Note that 2 questionnaires were returned with "address unknown" during the initial mail-out, and were excluded from the final total physician population. On March 16th, eight weeks after the initial mail-out, the final response rate for the

Terrier Health Authority for the post PACS physician survey was 35.0% (43/123) (Table 2).

Mastiff, Spaniel and Terrier Health Authorities (Combined)

The initial response rate for physicians in the three Health Authorities combined was 24.0% (224/932). Following the second mail-out, an additional 111 physicians completed the questionnaire, resulting in a final response rate of 36.3% (335/922) (Table 2)

Table 2
Post PACS Physician Response Summary
Mastiff, Spaniel and Terrier Health Authority

Survey Group	Mastiff Integrated Health Authority				Total
	1st Mail out Jan 17, 2007		2nd Mail out Feb 7, 2007		
	Mailed	Returned	Mailed	Returned	
Physicians	659	161 (24.4%)	654	80 (12.2%)	241 (36.9%)
	Spaniel Integrated Health Authority				
	Mailed	Returned	Mailed	Returned	
	148	36 (24.3%)	145	15 (10.3%)	51 (35.2%)
	Terrier Integrated Health Authority				
	Mailed	Returned	Mailed	Returned	
	125	27 (21.6%)	123	16 (13.0%)	43 (35.0%)
	Mastiff, Spaniel and Terrier (Combined)				
	Mailed	Returned	Mailed	Returned	
	932	224 (24.0%)	922	111 (12.0%)	335 (36.3%)

Pre PACS Survey: Radiologists

All Radiologists in the Terrier Health Authority were administered a questionnaire 3-months pre PACS implementation.

Terrier Health Authority

The pre PACS radiologist questionnaire was mailed to all radiologists in the Terrier Health Authority (n=6) on September 12th, 2005, three months prior to PACS being implemented. After three weeks a total of 2 radiologists had returned completed questionnaires for an initial response rate of 33.3% (2/6). On October 3rd a second mail-out to all radiologists (n=6) resulted in no further responses. On November 5th, eight weeks after the initial mail-out, the final response rate for the Terrier Health Authority for the pre PACS radiologist survey was 33.3% (2/6) (Table 3).

Table 3
Pre PACS Radiologist Response Summary
Terrier Health Authority

Survey Group	Terrier Integrated Health Authority				Total
	1st Mail out Sept 12, 2005		2nd Mail out Oct 3, 2005		
	Mailed	Returned	Mailed	Returned	
Radiologists	6	2 (33.3%)	6	0 (0.0%)	2 (33.3%)

Post PACS Survey: Radiologists

All radiologists in the Mastiff, Spaniel, and Terrier Health Authorities were administered a questionnaire post PACS implementation.

Mastiff Health Authority

The post PACS radiologist questionnaire was mailed to all radiologists in the Mastiff Health Authority (n=37) on January 17^{th}, 2007. After three weeks a total of 20 radiologists had returned completed questionnaires for an initial response rate of 54.1% (20/37). On February 7^{th} a second mail-out to all radiologists (n=33) resulted in no additional radiologist responding. Note that 4 questionnaires were returned with "address unknown" during the initial mail-out, and were excluded from the final total radiologist population. On March 16^{th}, eight weeks after the initial mail-out, the final response rate for the Mastiff Health Authority for the post PACS radiologist survey was 60.6% (20/33).

Spaniel Health Authority

The post PACS radiologist questionnaire was mailed to all radiologists in the Spaniel Health Authority (n=7) on January 17^{th}, 2007. After three weeks a total of 2 radiologists had returned completed questionnaires for an initial response rate of 28.6% (2/7). On February 7^{th} a second mail-out to all radiologists (n=7) resulted in no additional radiologist responding. On March 16^{th}, eight weeks after the initial mail-out, the final response rate for the Spaniel Health Authority for the post PACS radiologist survey was 28.6% (2/7).

Terrier Health Authority

The post PACS radiologist questionnaire was mailed to all radiologists in the Terrier Health Authority (n=6) on January 17th, 2007. After three weeks a total of 5 radiologists had returned completed questionnaires for an initial response rate of 83.3% (5/6). On February 7th a second mail-out to all radiologists (n=6) resulted in no additional radiologist responding. On March 16th, eight weeks after the initial mail-out, the final response rate for the Terrier Health Authority for the post PACS radiologist survey was 83.3% (5/6).

Mastiff, Spaniel and Terrier Health Authorities (Combined)

The initial response rate for radiologists in the three Health Authorities combined was 58.7% (27/46). Following the second mail-out, no additional radiologists returned a completed the questionnaire, resulting in a final response rate of 58.7% (27/46) (Table 4).

Table 4
Post PACS Radiologist Response Summary
Mastiff, Spaniel and Terrier Health Authority

Survey Group	Mastiff Integrated Health Authority				Total
	1st Mail out Jan 17, 2007		2nd Mail out Feb 7, 2007		
	Mailed	Returned	Mailed	Returned	
Radiologists	37	20 (54.1%)	33	0 (0.0%)	20 (60.6%)
	Spaniel Integrated Health Authority				
	Mailed	Returned	Mailed	Returned	
	7	2 (28.6%)	7	0 (0.0%)	2 (28.6%)
	Terrier Integrated Health Authority				
	Mailed	Returned	Mailed	Returned	
	6	5 (83.3%)	6	0 (0.0%)	5 (83.3%)
	Mastiff, Spaniel and Terrier Combined				
	Mailed	Returned	Mailed	Returned	
	50	27 (54.0%)	46	0 (0.0%)	27 (58.7%)

Pre PACS Survey: Radiology Technologists

All radiology technologists in the Terrier Health Authority were administered a questionnaire 3-months pre PACS implementation.

Terrier Health Authority

The pre PACS technologist questionnaire was delivered by the Diagnostic Imaging Director to the radiology technologists in the Terrier Health Authority (n=45) on September 12th, 2005, three months prior to PACS being implemented. After three weeks a total of 12 technologists had returned completed questionnaires for an initial response rate of 26.7% (12/45). On October 3rd the Diagnostic Imaging Director again delivered questionnaires to all technologists (n=45). This second delivery resulted in 6 additional technologists responding, for a 13.3% (6/45) response. On November 5th eight weeks after the Diagnostic Imaging Director delivered the first set questionnaires to the technologists, the final response rate for the Terrier Health Authority pre PACS technologist survey was 40.0% (18/45) (Table 5).

Table 5
Pre PACS Radiology Technologist Response Summary
Terrier Health Authority

Survey Group	Terrier Integrated Health Authority				Total
	1st Mail out Sept 12, 2005		2nd Mail out Oct 3, 2005		
	Delivered	Returned	Delivered	Returned	
Technologists	45	12 (26.7%)	45	6 (13.3%)	18 (40.0%)

Post PACS Survey: Radiology Technologists

All radiology technologists in the Terrier Health Authority were administered a questionnaire 12 months post PACS implementation.

Terrier Health Authority

The post PACS technologist questionnaire was delivered by the Diagnostic Imaging Director to the radiology technologists in the Terrier Health Authority (n=45) on January 17th, 2007, 12 months following the implementation of PACS. After three weeks a total of 21 technologists had returned completed questionnaires for an initial response rate of 46.7% (21/45). On February 3rd, 2007 the Diagnostic Imaging Director again delivered questionnaires to all technologists (n=45). This second delivery resulted in 7 additional technologists responding, for a 15.6% (7/45) response. On March 16th, eight weeks after the Diagnostic Imaging Director delivered the first set of questionnaires to the technologists, the final response rate for the Terrier Health Authority post PACS technologist survey was 62.2% (28/45) (Table 6).

Table 6
Post PACS Radiology Technologist Response Summary
Terrier Health Authority

Survey Group	Terrier Integrated Health Authority				Total
	1st Mail out Jan 17, 2007		2nd Mail out Feb 7, 2007		
	Delivered	Returned	Delivered	Returned	
Technologists	45	21 (46.7%)	45	7 (15.6%)	28 (62.2%)

Appendix L

Detailed Results of Surveys

Appendix L-1

Referring Physicians: Pre PACS Implementation Survey
Terrier Health Authority
(n=38)

Table 1
Regional Health Authority

Regional Integrated Health Authority	Total Responding (N=120)	(n%)
Mastiff		
Spaniel		
Terrier	38	31.7

Table 2
Usage of Film: Referring Physicians

How often you use film in the following ways	Total Responding (n=38)	Response					
		Never	Rarely	Sometimes	Frequently	Always	N/A
Clinical assessment	38 (100.0%)	5 (13.2)	0 (0.0)	9 (23.7)	17 (44.7)	7 (18.4)	0
Clinical diagnosis	38 (100.0%)	3 (7.9)	2 (5.3)	9 (23.7)	17 (44.7)	7 (18.4)	0
Clinical treatment	37 (97.4%)	3 (8.1)	5 (13.5)	8 (21.6)	14 (37.8)	7 (18.9)	1
Professional education	32(84.2%)	9 (28.1)	8 (25.0)	10 (31.3)	3 (9.4)	2 (6.3)	6
Rounds	32(84.2%)	11 (34.4)	8 (25.0)	8 (25.0)	4 (12.5)	1 (3.1)	6
Patient education	31(81.6%)	6 (19.4)	11 (35.5)	9 (29.0)	5 (16.1)	0 (0.0)	7
Health services research	32(84.2%)	23 (71.9)	7 (21.9)	0 (0.0)	2 (6.3)	0 (0.0)	6
Other	9(23.7%)	7 (77.8)	1 (11.1)	0 (0.0)	1 (11.1)	0 (0.0)	29

N/A = no response or not applicable

Table 3
Locating of Film and Reports: Referring Physicians

To what extent you agree or disagree with the following	Total Responding (n=38)	Response				
		Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
I can always find film when I need it	37(97.4%)	8 (21.6)	7 (18.9)	14 (37.8)	8 (21.6)	1
I can always find a report when I need it	36(94.7%)	8 (22.2)	11 (30.6)	12 (33.3)	5 (13.9)	2

N/A = no response or not applicable

Table 4
Time Spent Managing Film and Reports: Referring Physicians

Function	Total Responding (n=38)	Average Time in Minutes
What is the average time per day you spend looking for film?	19(50.0%)	16.2
What is the average time per day you spend looking for reports?	27(71.0%)	24.2
What is the average time per day you spend managing and handling films?	19(50.0%)	26.6

Table 5
Delay in Clinical Schedule: Referring Physicians

Delay in Clinical Schedule	Total Responding (n=38)	Response					
		Never	Rarely	Sometimes	Very Often	Always	N/A
How often is your clinical schedule delayed because of a delay in obtaining prior exams?	35(92.1%)	1 (2.9)	4 (11.4)	22 (62.9)	7 (20.0)	1 (2.9)	3

N/A = no response or not applicable

Table 6
Retrieving Film and Reports: Referring Physicians

How satisfied are you with the amount of time it takes to retrieve:	Total Responding (n=38)	Response				
		Very Dissatisfied	Dissatisfied	Satisfied	Very Satisfied	N/A
Film	34(89.5%)	0 (0.0)	14 (41.2)	17 (50.0)	3 (8.8)	4
Reports	35(92.1%)	5 (14.3)	14 (40.0)	13 (37.1)	3 (8.6)	3

N/A = no response or not applicable

Table 7
Managing Patient Care: Referring Physicians

How important are the following in managing patient care	Total Responding (n=38)	Response				
		Not at all Important	Not Very Important	Somewhat Important	Very Important	N/A
Film	36(94.7%)	0 (0.0)	1 (2.8)	18 (50.0)	17 (47.2)	2
Reports	36(94.7%)	0 (0.0)	1 (2.8)	4 (11.1)	31 (86.1)	2

N/A = no response or not applicable

Table 8
Accessing Historical Film and Reports: Referring Physicians

How often do you look at historical:	Total Responding (n=38)	Response					
		Never	Rarely	Sometimes	Very Often	Always	N/A
Film	37(97.4%)	3 (8.1)	2 (5.4)	14 (37.8)	16 (43.2)	2 (5.4)	1
Reports	37(97.4%)	1 (2.7)	0 (0.0)	5 (13.5)	22 (59.5)	9 (24.3)	1

N/A = no response or not applicable

Table 9
Referring to Historical Film: Referring Physicians

Referring to Historical Film	Total Responding (n=38)	Response (in Months)					
		<3	3-6	6-12	12-18	>18	N/A
After how much time is a film no longer referred to in the patient care process?	15(39.5%)	2 (13.3)	2 (13.3)	1 (6.7)	1 (6.7)	9 (60.0)	23

N/A = no response or not applicable

Note: 27of the 38 (77.1%) respondents indicated it depended on the clinical context

Table 10
Hospital Sites Worked in: Referring Physicians

Hospitals	Total Responding (n=38)	Hospitals
How many hospital sites do you work in?	37(97.4%)	1.3

Table 11
Hours Traveling Between Sites: Referring Physicians

Function	Total Responding (n=38)	Average Time in Hours
Please estimate the number of hours per week you spend traveling between hospital sites?	18(47.4%)	0.78

Note: 14 respondents indicated travel between hospitals was not applicable, 6 did not answer

Table 12
Accessing of Film and Reports: Referring Physicians

Where do you currently access film/reports?	Total Responding (n=38)	Yes Response
Medical Imaging		
Film	38 (100.0%)	33 (86.8)
Reports	38 (100.0%)	22 (57.9)
Private Office		
Film	38 (100.0%)	6 (15.8)
Reports	38 (100.0%)	25 (65.8)
Home Office		
Film	38 (100.0%)	1 (2.6)
Reports	38 (100.0%)	3 (7.9)

Table 13
Frequency of Accessing Film and Reports: Referring Physicians

Frequency of Accessing Film and Reports	Total Responding (n=38)	Response		
		Film	Reports	Both
What do you access most frequently?	36(94.7%)	3 (8.3)	22 (61.1)	11 (30.6)

Table 14
Perceived Benefits of PACS Pre-Implementation: Referring Physicians

Perceived Benefit	Total Responding (n=38)	Response				
		Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
PACS will reduce the time to review an exam	33 (86.8%)	2 (6.1)	0 (0.0)	9 (27.3)	22 (66.7)	5
I will access exams more frequently with PACS than I do with film	33 (86.8%)	2 (6.1)	1 (3.0)	10 (30.3)	20 (60.6)	5
I believe that report turnaround time will improve with PACS	33 (86.8%)	1 (3.0)	6 (18.2)	11 (33.3)	15 (45.5)	5
I believe that having access to PACS will improve the quality of the report	32 (84.2%)	4 (12.5)	2 (6.3)	12 (37.5)	14 (43.8)	6
PACS will facilitate consultation between myself and other clinicians	33 (86.8%)	1 (3.0)	4 (12.1)	5 (15.2)	23 (69.7)	5
My efficiency will improve because of PACS	33 (86.8%)	2 (6.1)	4 (12.1)	14 (42.4)	13 (39.4)	5
PACS will improve my ability to make decisions regarding patient care	33 (86.8%)	0 (0.0)	4 (12.1)	16 (48.5)	13 (39.4)	5
PACS will lead to a reduction in my patients' length of stay in hospital	29 (76.3%)	2 (6.9)	8 (27.6)	11 (37.9)	8 (27.6)	9
PACS will reduce the number of patient transfers between facilities	30 (78.9%)	3 (10.0)	5 (16.7)	12 (40.0)	10 (33.3)	8
PACS will reduce the number of exams reordered	32 (84.2%)	2 (6.3)	3 (9.4)	12 (37.5)	15 (46.9)	6
PACS will enhance patient care and service delivery in rural Newfoundland and Labrador	33 (86.8%)	0 (0.0)	2 (6.1)	10 (30.3)	21 (63.6)	5

N/A = no response or not applicable

Table 15
Perceived Challenges with the PACS Pre-Implementation: Referring Physicians

Perceived Challenge	Total Responding (n=38)	Response				
		Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
PACS will produce inadequate image quality on the Web	33 (86.8%)	4 (12.1)	12 (36.4)	13 (39.4)	4 (12.1)	5
PACS will produce inadequate image quality on the workstation	33 (86.8%)	5 (15.2)	16 (48.5)	8 (24.2)	4 (12.1)	5
I will have difficulty finding images when needed	36 (94.7%)	11 (30.6)	18 (50.0)	5 (13.9)	2 (5.6)	2
I will experience inadequate Web performance (speed)	34 (89.5%)	9 (26.5)	12 (35.3)	9 (26.5)	4 (11.8)	4
I will experience inadequate workstation performance (speed)	34 (89.5%)	10 (29.4)	13 (38.2)	9 (26.5)	2 (5.9)	4
I will have inadequate access to PACS viewing stations (PCs with Web or Workstations)	36 (94.7%)	9 (25.0)	11 (30.6)	10 (27.8)	6 (16.7)	2
I will have difficulty logging on to the system	36 (94.7%)	11 (30.6)	18 (50.0)	3 (8.3)	4 (11.1)	2
PACS downtime will be higher than acceptable	35 (92.1%)	6 (17.1)	16 (45.7)	11 (31.4)	2 (5.7)	3
I will receive insufficient training in the new technology	33 (86.8%)	5 (15.2)	16 (48.5)	7 (21.2)	5 (15.2)	5
I will be unable to view images at the patient's bedside	34 (89.5%)	2 (5.9)	8 (23.5)	10 (29.4)	14 (41.2)	4
I will experience a lack of availability of system support	35 (92.1%)	4 (11.4)	12 (34.3)	12 (34.3)	7 (20.0)	3

N/A = no response or not applicable

Table 16
Demographics – Referring Physicians

Demographic	Count (%)
Gender	
Male	31 (81.6)
Female	7 (18.4)
Total	38 (100.0)
Years in Practice	
< 2	1 (2.6)
2 to 5	3 (7.9)
6 to 10	3 (7.9)
11 to 15	3 (7.9)
16 to 20	10 (26.3)
21 to 25	9 (23.7)
> 25	9 (23.7)
Total	38 (100.0)
Number of Work Sites	
1	33 (89.2)
2	1 (2.7)
3	2 (5.4)
6	1 (2.7)
Total	37 (97.4)

Table 17
Experience with PACS: Referring Physicians

Have you had experience with PACS prior to this implementation project?	**Total Responding (n=38)**	**Percent**
Yes	6	16.2
No	31	83.8
Total	37(97.4)	100.0

Table 18
Referring Physician Specialty

Specialty	Total Responding (n=38)	Yes Response
Internal Medicine	2	5.3%
Obstetrics/Gynecology	2	5.3%
Pediatrics	2	5.3%
Neurology	2	5.3%
Family Practitioner /General Practitioner	20	52.6%
Orthopedics	1	2.6%
Gastroenterology	1	2.6%
General Surgery	1	2.6%
Pathology	1	2.6%
Palliative Medicine	1	2.6%
Ophthalmology	1	2.6%
Other	4	10.5%
Total	38(100.0%)	100.0%

Appendix L-2

Referring Physicians: Post PACS Implementation Survey
Terrier Health Authority
(n=43)

Table 1
Regional Health Authority

Regional Integrated Health Authority	Total Responding (N=123)	(n%)
Mastiff		
Spaniel		
Terrier	43	35.0

Table 2
PACS Experience

Have you had experience with PACS prior to this implementation project?	Total Responding (n=43)	n (%)
Yes	35	81.4
No	8	18.6
Total	43(100.0)	100.0

Table 3
Previous PACS Experience

How may years of PACS experience have you had?	Total Responding (n=43)	n (%)
<1	9	25.7
1-2	23	65.7
3-5	3	8.6
6-10	0	0.0
> 10	0	0.0
Total	35(81.4%)	100.0
Mean	1.3	0.77
Median	1.0	
Range	3.5	

Table 4
Where Accessing PACS

Where do you access the PACS System?	**Total Responding (n=43)**	**n (%)**
Medical Imaging	17	39.5
Clinics/Units/Patient Floors	40	93.0
Private Office	14	32.6
Home	2	4.7

Table 5
Accessing Reports/Exams

What do you access most frequently?	**Total Responding (n=43)**	**n (%)**
Exams	7	16.3
Reports	3	7.0
Both	33	76.7
Total	43(100.0)	100.0

Table 6
Perceived Benefits of PACS Post Implementation: Referring Physicians

Perceived Benefit	Total Responding (n=43)	Response				
		Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
PACS has reduced the time I spend locating exams for review	42 (97.7%)	2 (4.8)	3 (7.1)	10 (23.8)	27 (64.3)	1
I access prior exams more frequently with PACS than I did with film.	43 (100%)	0 (0.0)	8 (18.6)	11 (25.6)	24 (55.8)	0
I believe that report turnaround time has improve because of PACS	41 (95.3%)	3 (7.3)	10 (24.4)	15 (36.6)	13 (31.7)	2
I believe that PACS tools and functionality improve the quality of my report	42 (97.7%)	1 (2.4)	3 (7.1)	20 (47.6)	18 (42.9)	1
PACS has facilitated consultation between myself, other clinicians and/or radiologists at other health care locations	42 (97.7%)	1 (2.4)	7 (16.7)	17 (40.5)	17 (40.5)	1
My efficiency has improved because of PACS	43 (100%)	2 (4.7)	10 (23.3)	18 (41.9)	13 (30.2)	0
PACS has improved my ability to make decisions regarding patient care	41 (95.3%)	2 (4.9)	6 (14.6)	18 (43.9)	15 (36.6)	2
PACS has led to a reduction in my patients' length of stay in hospital	37 (86.0%)	5 (13.5)	17 (45.9)	9 (24.3)	6 (16.2)	6
PACS has reduced the number of patient transfers between facilities due to the ability to share images and consult remotely	35 (81.4%)	2 (5.7)	10 (28.6)	17 (48.6)	6 (17.1)	8
PACS has reduced the number of exams reordered because the exams were not available (lost or located elsewhere) when I need them	40 (93.0%)	2 (5.0)	12 (30.0)	17 (42.5)	9 (22.5)	3
PACS has enhanced patient care and service delivery in rural Newfoundland and Labrador	42 (97.7%)	0 (0.0)	3 (7.1)	20 (47.6)	19 (45.2)	1

N/A = no response or not applicable

Table 7
Perceived Challenges with PACS Post Implementation: Referring Physicians

Perceived Benefit	Total Responding (n=43)	Response				
		Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
PACS produces inadequate image quality on the Web (e.g. from home)	27 (62.8%)	2 (7.4)	15 (55.6)	7 (25.9)	3 (11.1)	16
PACS produces inadequate image uality on the hospital workstation	41 (95.3%)	15 (36.6)	21 (51.2)	2 (4.9)	3 (7.3)	2
I have difficulty finding images when needed	43 (100%)	16 (37.2)	16 (37.2)	8 (18.6)	3 (7.0)	0
I experience inadequate Web performance (speed)	42 (97.7%)	12 (28.6)	21 (50.0)	6 (14.3)	3 (7.1)	1
I experience inadequate workstation performance (speed)	42 (97.7%)	11 (26.2)	16 (38.1)	12 (28.6)	3 (7.1)	1
I have inadequate access to PACS viewing stations (PCs with Web or Workstations)	42 (97.7%)	18 (42.9)	13 (31.0)	9 (21.4)	2 (4.8)	1
I have difficulty logging on to the system	43 (100%)	18 (41.9)	15 (34.9)	7 (16.3)	3 (7.0)	0
PACS downtime is higher than acceptable	42 (97.7%)	15 (35.7)	17 (40.5)	7 (16.7)	2 (4.8)	1
I received insufficient training in the new technology	42 (97.7%)	7 (16.7)	21 (50.0)	8 (19.0)	6 (14.3)	1
I am unable to view images at the patient's bedside	36 (83.7%)	2 (5.6)	7 (19.4)	9 (25.0)	18 (50.0)	7
I experience a lack of availability of system support	40 (93.0%)	9 (22.5)	16 (40.0)	11 (27.5)	4 (10.0)	3
The implementation /installation from film to PACS was well managed	41 (95.3%)	2 (4.9)	6 (14.6)	20 (48.8)	13 (31.7)	1

N/A = no response or not applicable

Table 8
Gender

Gender	Total Responding (n=43)	n (%)
Male	33	76.7
Female	10	23.3
Total	43(100.0)	100.0

Table 9
Years in Practice

Years	Total Responding (n=43)	n (%)
< 2 Years	2	4.7
2-5	4	9.3
6-10	9	20.9
11-15	3	7.0
16-20	6	14.0
21-25	4	9.3
25+	15	34.9
Total	43(100.0)	100.0

Table 10
Physician Specialty

Specialty	Total Responding (n=43)	Yes Response
Internal Medicine	5	11.6
Obstetrics/Gynecology	3	7.0
Pediatrics	1	2.3
Emergency Medicine	4	9.3
Family Practitioner /General Practitioner	19	44.2
Orthopedics	2	4.7
General Surgery	3	7.0
Pathology	2	4.7
Palliative Medicine	1	2.3
Ophthalmology	1	2.3
Other	2	4.7
Total	43 (100.0)	100.0

Appendix L-3

Referring Physicians: Post PACS Implementation Survey
Mastiff, Spaniel and Terrier Combined
(n=335)

Table 1
Regional Health Authority

Regional Integrated Health Authority	Total Responding (N=922)	n (%)
Mastiff	241	71.9
Spaniel	51	15.2
Terrier	43	12.8
Total	335(36.3)	100.0

Table 2
PACS Experience

Have you had experience with PACS prior to this implementation project?	Total Responding (n=335)	n (%)
Yes	276	83.6
No	54	16.4
Total	330(98.5%)	100.0

Table 3
Previous PACS Experience

How many years of PACS experience have you had?	Total Responding (n=335)	n (%)
<1	21	7.7
1-2	136	49.8
3-5	92	33.7
6-10	24	8.8
> 10	0	0.0
Total	273(81.5)	100.0
Mean	2.7	1.9
Median	2.0	
Range	9.7	

Table 4
Where Accessing PACS

Where do you access the PACS System?	**Total Responding (n=335)**	**n (%)**
Medical Imaging	149	45.3
Clinics/Units/Patient Care Floors	284	86.3
Private Office	93	28.3
Home	36	10.9
Total	329(98.2)	100.0

Table 5
Accessing Reports/Exams

What do you access most frequently?	**Total Responding (n=335)**	**n (%)**
Exams	92	27.8
Reports	27	8.2
Both	212	64.0
Table	331(98.8)	100.0

Table 6
Perceived Benefits of PACS Post-Implementation: Referring Physicians

Perceived Benefit	Total Responding (n=335)	Response: Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
PACS has reduced the time I spend locating exams for review	325 (97.0%)	10 (3.1)	13 (4.0)	75 (23.1)	227 (69.8)	10
I access prior exams more frequently with PACS than I did with film.	320 (95.5%)	13 (4.1)	31 (9.7)	69 (21.6)	207 (64.7)	15
I believe that report turnaround time has improve because of PACS	322 (96.1%)	24 (7.5)	69 (21.4)	115 (35.7)	114 (35.4)	13
I believe that PACS tools and functionality improve the quality of my report	316 (94.3%)	12 (3.8)	46 (14.6)	135 (42.7)	123 (38.9)	19
PACS has facilitated consultation between myself, other clinicians and/or radiologists at other health care locations	315 (94.0%)	15 (4.8)	34 (10.8)	117 (34.9)	149 (47.3)	20
My efficiency has improved because of PACS	326 (97.3%)	13 (4.0)	37 (11.3)	124 (38.0)	152 (46.6)	9
PACS has improved my ability to make decisions regarding patient care	320 (95.5%)	15 (4.7)	49 (15.3)	117 (36.6)	139 (43.4)	15
PACS has led to a reduction in my patients' length of stay in hospital	260 (77.6%)	48 (18.5)	97 (37.3)	70 (26.9)	45 (17.3)	75
PACS has reduced the number of patient transfers between facilities due to the ability to share images and consult remotely	262 (78.2%)	20 (7.6)	68 (26.0)	112 (42.7)	62 (23.7)	73
PACS has reduced the number of exams reordered because the exams were not available (lost or located elsewhere) when I need them	302 (90.1%)	21 (7.0)	59 (19.5)	131 (43.4)	91 (30.1)	33
PACS has enhanced patient care and service delivery in rural Newfoundland and Labrador	296 (88.3%)	8 (2.7)	15 (5.1)	110 (37.2)	163 (55.1)	39

N/A = no response or not applicable

Table 7
Perceived Challenges of PACS Post -Implementation: Referring Physicians

Perceived Benefit	Total Responding (n=335)	Response				
		Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
PACS produces inadequate image quality on the Web (e.g. from home)	196 (58.5%)	33 (16.8)	66 (33.7)	72 (36.7)	25 (12.8)	139
PACS produces inadequate image uality on the hospital workstation	302 (90.1%)	107 (35.4)	110 (36.4)	61 (20.2)	24 (7.9)	33
I have difficulty finding images when needed	317 (94.6%)	129 (40.7)	126 (39.7)	50 (15.8)	12 (3.8)	18
I experience inadequate Web performance (speed)	285 (85.1%)	80 (28.1)	116 (40.7)	70 (24.6)	19 (6.7)	50
I experience inadequate workstation performance (speed)	305 (91.0%)	98 (32.1)	119 (39.0)	73 (23.9)	15 (4.9)	30
I have inadequate access to PACS viewing stations (PCs with Web or Workstations)	318 (94.9%)	104 (32.7)	121 (38.1)	67 (21.1)	26 (8.2)	17
I have difficulty logging on to the system	322 (96.1%)	134 (41.6)	119 (37.0)	49 (15.2)	20 (6.2)	13
PACS downtime is higher than acceptable	322 (96.1%)	111 (34.4)	142 (44.1)	53 (16.5)	16 (5.0)	13
I received insufficient training in the new technology	317 (94.6%)	69 (6.3)	99 (31.2)	89 (28.1)	60 (18.9)	18
I am unable to view images at the patient's bedside	268 (80.0%)	30 (11.2)	55 (20.5)	76 (28.4)	107 (40.0)	67
I experience a lack of availability of system support	295 (88.1%)	67 (22.7)	125 (42.3)	77 (26.1)	26 (8.8)	40
The implementation /installation from film to PACS was well managed	293 (87.5%)	29 (9.9)	40 (13.7)	140 (47.8)	84 (28.7)	42

N/A = no response or not applicable

Table 8
Gender

Gender	**Total Responding (n=335)**	**n (%)**
Male	240	72.3
Female	92	27.7
Total	332(99.1)	100.0

Table 9
Years in Practice

Years	**Total Responding (N=334)**	**n (%)**
< 2 Years	17	5.1
2-5	35	10.5
6-10	53	15.9
11-15	44	13.2
16-20	58	17.4
21-25	44	13.2
25+	83	24.9
Total	334(99.7)	100.0

Table 10
Referring Physician Specialty

Specialty	Total Responding (n=335)	Percent
Cardiology	3	0.9
Internal Medicine	31	9.3
Obstetrics/Gynecology	18	5.4
Pediatrics	36	10.7
Thoracic Surgery	2	0.6
Emergency Medicine	37	11.0
Nephrology	3	0.9
Oncology	9	2.7
Family Practitioner /General Practitioner	95	28.4
Neurology	6	1.8
Orthopedics	9	2.7
Neurosurgery	5	1.5
Orthopedic Surgery	4	1.2
Vascular Surgery	3	0.9
General Surgery	18	5.4
Pathology	7	2.1
Palliative Medicine	2	0.6
Ophthalmology	4	1.2
Other	43	12.8
Total	335(100.0)	100.0

Appendix L-4

Radiologists: Pre PACS Implementation Survey
Terrier Health Authority
(n=2)

Table 1
Regional Health Authority

Regional Integrated Health Authority	Total Responding (N=6)	(n%)
Mastiff		
Spaniel		
Terrier	2	33.3

Table 2
Usage of Film: Radiologists

How often you use film in the following ways	Total (n=2)	Response					
		Never	Rarely	Sometimes	Frequently	Always	N/A
Clinical assessment	2 (100.0%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (100.0)	0
Clinical diagnosis	2 (100.0%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (100.0)	0
Clinical treatment	2 (100.0%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (100.0)	0
Professional education	0						
Rounds	2 (100.0%)	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	0
Patient education	2 (100.0%)	0 (0.0)	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)	0
Health services research	2 (100.0%)	2 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0
Other	0						

N/A = no response or not applicable

Table 3
Locating of Film and Reports: Radiologists

To what extent you agree or disagree with the following	Total (n=6)	Response				
		Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
I can always find film when I need it	2 (100.0%)	1 (50.0)	0 (0.0)	1 (50.0)	0 (0.0)	0
I can always find a report when I need it	2 (100.0%)	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)	0

N/A = no response or not applicable

Table 4
Time Spent Managing Film and Reports: Radiologists

Function	Total (n=2)	Average Time in Minutes
What is the average time per day you spend looking for film?	2 (100.0%)	40
What is the average time per day you spend looking for reports?	2 (100.0%)	35
What is the average time per day you spend managing and handling films?	2 (100.0%)	360

Table 5
Delay in Clinical Schedule: Radiologists

Delay in Clinical Schedule	Total (n=2)	Response					
		Never	Rarely	Sometimes	Very Often	Always	N/A
How often is your clinical schedule delayed because of a delay in obtaining prior exams?	2 (100.0%)	0(0.0)	0(0.0)	0(0.0)	1 (50.0)	1 (50.0)	0

N/A = no response or not applicable

Table 6
Retrieving Film and Reports: Radiologists

How satisfied are you with the amount of time it takes to retrieve:	Total (n=2)	Response				
		Very Dissatisfied	Dissatisfied	Satisfied	Very Satisfied	N/A
Film	2 (100.0%)	1 (50.0)	1 (50.0)	0(0.0)	0(0.0)	0
Reports	2 (100.0%)	1 (50.0)	1 (50.0)	0(0.0)	0(0.0)	0

N/A = no response or not applicable

Table 7
Managing Patient Care: Radiologists

How important are the following in managing patient care	Total (n=2)	Response				
		Not at all Important	Not Very Important	Somewhat Important	Very Important	N/A
Film	2 (100.0%)	0(0.0)	0(0.0)	0(0.0)	2 (100.0)	0
Reports	2 (100.0%)	0(0.0)	0(0.0)	0(0.0)	2 (100.0)	0

N/A = no response or not applicable

Table 8
Accessing Historical Film and Reports: Radiologists

How often do you look at historical:	Total (n=2)	Response					
		Never	Rarely	Sometimes	Very Often	Always	N/A
Film	2 (100.0%)	0(0.0)	0(0.0)	0(0.0)	1 (50.0)	1 (50.0)	0
Reports	2 (100.0%)	0(0.0)	0(0.0)	0(0.0)	1 (50.0)	1 (50.0)	0

N/A = no response or not applicable

Table 9
Referring to Historical Film: Radiologists

Referring to Historical Film	Total (n=2)	Response (in Months)					
		<3	3-6	6-12	12-18	>18	N/A
After how much time is a film no longer referred to in the patient care process?	0 (0.0%)						

Note: 2 respondents (100.0%) indicated it depended on the clinical context

Table 10
Hospital Sites Worked in: Radiologists

Hospitals	Total (n=2)	Hospitals
How many hospital sites do you work in??	2 (100.0%)	1

Table 11
Hours Traveling Between Sites: Radiologists

Function	Total (n=2)	Average Time in Hours
Please estimate the number of hours per week you spend traveling between hospital sites?	0 (0.0%)	

Note: 2 respondents (100.0%) indicated it was non applicable

Table 12
Accessing of Film and Reports: Radiologists

Where do you currently access film/reports?	**Total (n=2)**	**Yes**
Medical Imaging		
Film	2 (100.0%)	2 (100.0)
Reports	2 (100.0%)	2 (100.0)
Private Office		
Film	2 (100.0%)	2 (100.0)
Reports	2 (100.0%)	2 (100.0)
Home Office		
Film	2 (100.0%)	0 (0.0)
Reports	2 (100.0%)	0 (0.0)

Table 13
Frequency of Accessing of Film and Reports: Radiologists

Frequency of Accessing Film and Reports	**Total (n=2)**	**Response**		
		Film	Reports	Both
What do you access most frequently?	2 (100.0%)	0(0.0)	0(0.0)	2 (100.0)

Table 14
Perceived Benefits of PACS Pre Implementation: Radiologists

Perceived Benefit	Total (n=2)	Response				
		Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
PACS will reduce the time to review an exam	2 (100.0%)	1 (50.0)	0 (0.0)	0 (0.0)	1 (50.0)	0
I will access exams more frequently with PACS than I do with film	2 (100.0%)	1 (50.0)	0 (0.0)	1 (50.0)	0 (0.0)	0
I believe that report turnaround time will improve with PACS	2 (100.0%)	1 (50.0)	0 (0.0)	0 (0.0)	1 (50.0)	0
I believe that having access to PACS will improve the quality of the report	2 (100.0%)	1 (50.0)	0 (0.0)	1 (50.0)	0 (0.0)	0
PACS will facilitate face to face consultation between myself and other radiologists	2 (100.0%)	1 (50.0)	0 (0.0)	1 (50.0)	0 (0.0)	0
PACS will facilitate phone consultation between myself and other radiologists	2 (100.0%)	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)	0
My efficiency will improve because of PACS	2 (100.0%)	1 (50.0)	0 (0.0)	0 (0.0)	1 (50.0)	0
PACS will improve my ability to make decisions regarding patient care	N/A	N/A	N/A	N/A	N/A	N/A
PACS will lead to a reduction in my patients' length of stay in hospital	N/A	N/A	N/A	N/A	N/A	N/A
PACS will reduce the number of patient transfers between facilities	N/A	N/A	N/A	N/A	N/A	N/A
PACS will reduce the number of exams reordered	N/A	N/A	N/A	N/A	N/A	N/A
PACS will enhance patient care and service delivery in rural Newfoundland and Labrador	2 (100.0%)	1 (50.0)	0 (0.0)	0 (0.0)	1 (50.0)	0

N/A = no response or not applicable

Table 15
Perceived Challenges with the PACS Pre-Implementation: Radiologists

Perceived Challenge	Total Responding (n=2)	Response				
		Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
PACS will produce inadequate image quality on the Web	2 (100.0%)	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	0
PACS will produce inadequate image quality on the workstation	2 (100.0%)	2 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0
I will have difficulty finding images when needed	2 (100.0%)	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	0
I will experience inadequate Web performance (speed)	1 (50.0%)	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0
I will experience inadequate workstation performance (speed)	2 (100.0%)	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	0
I will have inadequate access to PACS viewing stations (PCs with Web or Workstations)	2 (100.0%)	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	0
I will have difficulty logging on to the system	2 (100.0%)	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)	0
PACS downtime will be higher than acceptable	2 (100.0%)	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)	0
I will receive insufficient training in the new technology	2 (100.0%)	2 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0
I will be unable to view images at the patient's bedside	N/A	N/A	N/A	N/A	N/A	N/A
I will experience a lack of availability of system support	2 (100.0%)	2 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0

N/A = no response or not applicable

Table 16
Demographics – Radiologists

Demographic	Count (%)
Gender	
Male	2 (100.0)
Female	0 (0.0)
Total	2 (100.0)
Years in Practice	
< 2	2 (100.0)
2 to 5	0 (0.0)
6 to 10	0 (0.0)
11 to 15	0 (0.0)
16 to 20	0 (0.0)
21 to 25	0 (0.0)
> 25	0 (0.0)
Total	2 (100.0)
Number of Work Sites	
1	2 (100.0)
2	0 (0.0)
3	0 (0.0)
6	0 (0.0)
Total	2 (100.0)

Table 17
Experience with PACS: Radiologists

Have you had experience with PACS prior to this implementation project?	Total Responding (n=2)	Percent
Yes	2	100.0
No	0	0.0

Table 18
Radiologist Specialty

Specialty	Total Responding (n=2)	Response
Radiologist Physician	2	Percent
Nuclear Medicine	0	0.0

Appendix L-5

Radiologists: Post PACS Implementation Survey
Terrier Health Authority
(n=5)

Table 1
Regional Health Authority

Regional Integrated Health Authority	**Total Responding (N=6)**	**(n%)**
Mastiff		
Spaniel		
Terrier	5	83.3

Table 2
PACS Experience

Have you had experience with PACS prior to this implementation project?	**Total Responding (n=5)**	**n (%)**
Yes	4	80.0
No	1	20.0

Table 3
PACS Experience

How many years of PACS experience have you had?	**Total Responding (n=5)**	**n (%)**
<1	1	25.0
1-2	0	0.0
3-5	2	50.0
6-10	1	25.0
> 10	0	0.0
Total	4 (80.0)	100.0
Mean	3.7	2.3
Median	4.0	
Range	5.1	

Table 4
Where Accessing PACS

Where do you access the PACS System?	Total Responding (n=5)	n (%)
Medical Imaging	5	100.0
Clinics/Units/Patient Care Floors	5	100.0
Private Office	5	100.0
Home	4	80.0

Table 5
Accessing Reports/Exams

What do you access most frequently?	Total Responding (n=5)	n (%)
Exams	1	20.0
Reports	0	0.0
Both	4	80.0

Table 6
Perceived Benefits of PACS Post Implementation: Radiologists

Perceived Benefit	Total (n=5)	Response: Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
PACS has reduced the time I spend locating exams for review	5 (100.0%)	0 (0.0)	0 (0.0)	0 (0.0)	5 (100)	0
I access prior exams more frequently with PACS than I did with film.	5 (100.0%)	1 (20.0)	0 (0.0)	0 (0.0)	4 (80.0)	0
I believe that report turnaround time has improve because of PACS (i.e. time to report dictated or time to preliminary report available)	5 (100.0%)	0 (0.0)	0 (0.0)	1 (20.0)	4 (80.0)	0
I believe that PACS tools and functionality improve the quality of my report	5 (100.0%)	1 (20.0)	0 (0.0)	0 (0.0)	4 (80.0)	0
PACS has improved the quality and number of patient management rounds that I participate in	4 (80.0%)	1 (25.0)	1 (25.0)	1 (25.0)	1 (25.0)	1
PACS has increased the number of face to face consultations I have with physicians and other radiologists	5 (100.0%)	2 (40.0)	1 (20.0)	1 (20.0)	1 (20.0)	0
PACS has increased the number of phone (or other) consultations I have with physicians and other radiologists	5 (100.0%)	0 (0.0)	0 (0.0)	2 (40.0)	3 (60.0)	0
PACS has reduced my professional travel time	4 (80.0%)	1 (25.0)	0 (0.0)	2 (50.0)	1 (25.0)	1
PACS has improved medical student/radiology resident teaching	4 (80.0%)	0 (0.0)	1 (25.0)	1 (25.0)	2 (50.0)	1
With the implementation of PACS, I report remotely for sites to which I previously traveled	4 (80.0%)	2 (50.0)	1 (25.0)	0 (0.0)	1 (25.0)	1
With the implementation of PACS, I report remotely for new sites	2 (40.0%)	2 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	3
PACS has improved my reporting and consultation efficiency	5 (100.0%)	0 (0.0)	0 (0.0)	1 (20.0)	4 (80.0)	0
PACS has enhanced patient care and service delivery in rural Newfoundland and Labrador	5 (100.0%)	0 (0.0)	0 (0.0)	0 (0.0)	5 (100.0)	0

N/A = no response or not applicable

Table 7
Perceived Challenges of PACS Post Implementation: Radiologists

Perceived Benefit	Total Responding (n=5)	Response				
		Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
PACS produces inadequate image quality on the remote Web (e.g. from home).	4 (80.0%)	1 (25.0	1 (25.0)	1 (25.0)	1 (25.0)	1
PACS produces inadequate image quality on the workstation	5 (100.0%)	4 (80.0)	0 (0.0)	0 (0.0)	1 (20.0)	0
PACS provides inadequate functionality on the remote Web	4 (80.0%)	1 (25.0)	1 (25.0)	2 (50.0)	0 (0.0)	1
PACS produces inadequate functionality on the workstation	5 (100.0%)	3 (60.0)	1 (20.0)	0 (0.0)	1 (20.0)	0
I have difficulty finding images in PACS when I need them	5 (100.0%)	2 (40.0)	1 (20.0)	0 (0.0)	2 (40.0)	0
I experience inadequate remote Web performance (speed)	4 (80.0%)	0 (0.0)	1 (25.0)	2 (50.0)	1 (25.0)	1
I experience inadequate Workstation performance (speed)	5 (100.0%)	0 (0.0)	2 (40.0)	2 (40.0)	1 (20.0)	0
I experience inadequate access to PACS viewing stations	5 (100.0%)	3 (60.0)	0 (0.0)	0 (0.0)	2 (40.0)	0
I have difficulty logging on to the system	5 (100.0%)	3 (60.0)	0 (0.0)	0 (0.0)	2 (40.0)	0
PACS downtime is higher than acceptable	5 (100.0%)	0 (0.0)	2 (40.0)	2 (40.0)	1 (20.0)	0
I received insufficient training in the new technology	5 (100.0%)	1 (20.0)	2 (40.0)	0 (0.0)	2 (40.0)	0
I experience a lack of availability of system support	5 (100.0%)	2 (40.0)	1 (20.0)	0 (0.0)	2 (40.0)	0
The implementation /installation from film to PACS was well managed	5 (100.0%)	1 (20.0)	0 (0.0)	1 (20.0)	3 (60.0)	0

N/A = no response or not applicable

Table 8
Gender

Gender	**Total Responding (n=5)**	**n (%)**
Male	3	60.0
Female	2	40.0

Table 9
Years in Practice

Years	**Total Responding (n=5)**	**n (%)**
< 2 Years	3	60.0
2-5	0	0.0
6-10	0	0.0
11-15	0	0.0
16-20	2	40.0
21-25	0	0.0
25+	0	0.0
	5(100.0)	100.0

Table 10
Profession

Please indicate your profession	**Total Responding (n=5)**	**n (%)**
Radiologist Physician	5	100.0
Nuclear Medicine Specialists	0	0.0

Appendix L-6

Radiologists: Post PACS Implementation
Mastiff, Spaniel and Terrier Combined
(n=27)

Table 1
Response by Regional Health Authority

Regional Integrated Health Authority	Total Responding (N=46)	(n%)
Mastiff	20	74.1
Spaniel	2	7.4
Terrier	5	18.5
Total	27 (58.7)	100.0

Table 2
Previous PACS Experience

Have you had experience with PACS prior to this implementation project?	Total Responding (n=27)	n (%)
Yes	24	92.3
No	2	7.7
Total	26(96.3)	100.0

Table 3
PACS Experience

How may years of PACS experience have you had?	Total Responding (n=27)	n (%)
<1	1	4.0
1-2	7	28.0
3-5	14	56.0
6-10	3	12.0
> 10	0	0.0
Total	25(92.6)	100.0
Mean	3.5	2.2
Median	3.0	
Range	9.1	

Table 4
Where Accessing PACS

Where do you access the PACS System?	Total Responding (n=27)	n (%)
Medical Imaging	27	100.0
Clinics/Units/Patient Care Floors	2	7.4
Private Office	2	7.4
Home	12	44.4

Table 5
Accessing Reports/Exams

What do you access most frequently?	Total Responding (n=27)	n (%)
Exams	9	33.3
Reports	0	0.0
Both	18	66.7
Total	27(100.0)	100.0

Table 6
Perceived Benefits of PACS Post Implementation: Radiologists

Perceived Benefit	Total Responding (n=27)	Response				
		Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
PACS has reduced the time I spend locating exams for review	27 (100%)	1 (3.7)	0 (0.0)	1 (3.7)	25 (92.6)	0
I access prior exams more frequently with PACS than I did with film.	27 (100%)	3 (11.1)	3 (11.1)	8 (29.6)	13 (48.1)	0
I believe that report turnaround time has improve because of PACS (i.e. time to report dictated or time to preliminary report available)	27 (100%)	1 (3.7)	2 (7.4)	4 (14.8)	20 (74.1)	0
I believe that PACS tools and functionality improve the quality of my report	26 (96.3%)	2 (7.7)	1 (3.8)	3 (11.5)	20 (76.9)	1
PACS has improved the quality and number of patient management rounds that I participate in	24 (88.9%)	3 (12.5)	7 (29.2)	4 (16.7)	10 (41.7)	3
PACS has increased the number of face to face consultations I have with physicians and other radiologists	27 (100%)	10 (37.0)	10 (37.0)	4 (14.8)	3 (11.1)	0
PACS has increased the number of phone (or other) consultations I have with physicians and other radiologists	27 (100%)	5 (18.5)	3 (11.1)	10 (37.0)	9 (33.3)	0
PACS has reduced my professional travel time	20 (74.1%)	5 (25.0)	5 (25.0)	5 (25.0)	5 (25.0)	7
PACS has improved medical student/radiology resident teaching	21 (77.8%)	2 (9.5)	2 (9.5)	3 (14.3)	14 (66.7)	6
With the implementation of PACS, I report remotely for sites to which I previously traveled	22 (81.5%)	9 (40.9)	3 (13.6)	3 (13.6)	7 (31.8)	5
With the implementation of PACS, I report remotely for new sites	22 (81.5%)	8 (36.4)	1 (4.5)	2 (9.1)	11 (50.0)	5
PACS has improved my reporting and consultation efficiency	27 (100%)	1 (3.7)	0 (0.0)	3 (11.1)	23 (85.2)	0
PACS has enhanced patient care and service delivery in rural Newfoundland and Labrador	26 (96.3%)	0 (0.0)	0 (0.0)	4 (15.4)	22 (84.6)	1

N/A = no response or not applicable

Table 7
Perceived Challenges of PACS Post Implementation: Radiologists

Perceived Benefit	Total Responding (n=27)	Response				
		Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
PACS produces inadequate image quality on the remote Web (e.g. from home).	20 (74.1%)	3 (15.0)	8 (40.0)	3 (15.0)	6 (30.0)	7
PACS produces inadequate image quality on the workstation	26 (96.3%)	21 (80.8)	2 (7.7)	0 (0.0)	3 (11.5)	1
PACS provides inadequate functionality on the remote Web	22 (81.5%)	4 (18.2)	8 (36.4)	5 (22.7)	5 (22.7)	5
PACS produces inadequate functionality on the workstation	26 (96.3%)	20 (76.9)	3 (11.5)	0 (0.0)	3 (11.5)	1
I have difficulty finding images in PACS when I need them	27 (100%)	19 (70.4)	5 (18.5)	0 (0.0)	3 (11.1)	0
I experience inadequate remote Web performance (speed)	22 (81.5%)	5 (22.7)	5 (22.7)	7 (31.8)	5 (22.7)	5
I experience inadequate Workstation performance (speed)	27 (100%)	12 (44.4)	9 (33.3)	4 (14.8)	2 (7.4)	0
I experience inadequate access to PACS viewing stations	27 (100%)	20 (74.1)	3 (11.1)	1 (3.7)	3 (11.1)	0
I have difficulty logging on to the system	27 (100%)	20 (74.1)	4 (14.8)	1 (3.7)	2 (7.4)	0
PACS downtime is higher than acceptable	26 (96.3%)	14 (53.8)	7 (26.9)	3 (11.5)	2 (7.7)	1
I received insufficient training in the new technology	26 (96.3%)	9 (34.6)	8 (30.8)	4 (15.4)	5 (19.2)	1
I experience a lack of availability of system support	27 (100%)	8 (29.6)	9 (33.3)	6 (22.2)	4 (14.8)	0
The implementation /installation from film to PACS was well managed	27 (100%)	2 (7.4)	4 (14.8)	7 (25.9)	14 (51.9)	0

N/A = no response or not applicable

Table 8
Gender

Gender	Total Responding (n=27)	n (%)
Male	18	66.7
Female	9	33.3
Total	27 (100.0)	100.0

Table 9
Years in Practice

Years	Total Responding (n=27)	n (%)
< 2 Years	3	11.1
2-5	5	18.5
6-10	1	3.7
11-15	3	11.1
16-20	6	22.2
21-25	3	11.1
25+	6	22.2
Total	27(100.0)	100.0

Table 10
Profession

Please indicate your profession	Total Responding (n=27)	(n%)
Radiologist Physician	25	92.6
Nuclear Medicine Specialists	2	7.4
Total	27(100.0)	100.0

Appendix L-7

Radiology Technologists: Pre PACS Implementation
Terrier Health Authority
(n=18)

Table 1
Regional Health Authority

Regional Integrated Health Authority	Total Responding (N=43)	(n%)
Mastiff		
Spaniel		
Terrier	18	41.9

Table 2
Usage of Film: Radiology Technologists

How often you use film in the following ways	Total Responding (n=18)	Response					
		Never	Rarely	Sometimes	Frequently	Always	N/A
Clinical assessment	12(66.7%)	1 (8.3)	0 (0.0)	1 (8.3)	3 (25.0)	7 (58.3)	6
Clinical diagnosis	9(50.0%)	1 (11.1)	0 (0.0)	2 (22.2)	1 (11.1)	5 (55.6)	9
Clinical treatment	7(38.9%)	2 (28.6)	1 (14.3)	0 (0.0)	1 (14.3)	3 (42.9)	11
Professional education	11(61.1%)	2 (18.2)	2 (18.2)	4 (36.4)	2 (18.2)	1 (9.1)	7
Rounds	4(22.2%)	2 (50.0)	0 (0.0)	0 (0.0)	1 (25.0)	1 (25.0)	14
Patient education	6(33.3%)	5 (83.3)	0 (0.0)	1 (16.7)	0 (0.0)	0 (0.0)	12
Health services research	4(22.2%)	3 (75.0)	1 (25.0)	0 (0.0)	0 (0.0)	0 (0.0)	14
Other	0						18

N/A = no response or not applicable

Table 3
Locating of Film and Reports: Radiology Technologists

To what extent you agree or disagree with the following	Total Responding (n=18)	Response				
		Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
I can always find film when I need it	17(94.4%)	1 (5.9)	2 (11.8)	9 (52.9)	5 (29.4)	1
I can always find a report when I need it	17(94.4%)	1 (5.9)	3 (17.6)	9 (52.9)	4 (23.5)	1

N/A = no response or not applicable

Table 4
Time Spent Managing Film and Reports: Radiology Technologists

Function	Total Responding (n=18)	Average Time in Minutes
What is the average time per day you spend looking for film?	13(72.2%)	32.1
What is the average time per day you spend looking for reports?	14(77.8%)	20.9
What is the average time per day you spend managing and handling films?	17(94.4%)	196.5

Table 5
Delay in Clinical Schedule: Radiology Technologists

Delay in Clinical Schedule	Total Responding (n=18)	Response					
		Never	Rarely	Sometimes	Very Often	Always	N/A
How often is your clinical schedule delayed because of a delay in obtaining prior exams?	12(66.7%)	0 (0.0)	6 (50.0)	5 (41.7)	1 (8.3)	0 (0.0)	6

N/A = no response or not applicable

Table 6
Retrieving Film and Reports: Radiology Technologists

How satisfied are you with the amount of time it takes to retrieve:	Total Responding (n=18)	Response				
		Very Dissatisfied	Dissatisfied	Satisfied	Very Satisfied	N/A
Film	16(88.9%)	1 (6.3)	7 (43.8)	8 (50.0)	0 (0.0)	2
Reports	16(88.9%)	0 (0.0)	5 (31.3)	11 (68.8)	0 (0.0)	2

N/A = no response or not applicable

Table 7
Managing Patient Care: Radiology Technologists

How important are the following in managing patient care	Total Responding (n=18)	Response				
		Not at all Important	Not Very Important	Somewhat Important	Very Important	N/A
Film	13(72.2%)	0 (0.0)	0 (0.0)	2 (15.4)	11 (84.6)	5
Reports	13(72.2%)	0 (0.0)	0 (0.0)	0 (0.0)	13 (100.0)	5

N/A = no response or not applicable

Table 8
Accessing Historical Film and Reports: Radiology Technologists

How often do you look at historical:	Total Responding (n=18)	Response					
		Never	Rarely	Sometimes	Very Often	Always	N/A
Film	17(94.4%)	0 (0.0)	0 (0.0)	8 (47.1)	7 (41.2)	2 (11.8)	1
Reports	17(94.4%)	0 (0.0)	0 (0.0)	7 (41.2)	9 (52.9)	1 (5.9)	1

N/A = no response or not applicable

Table 9
Referring to Historical Film: Radiology Technologists

Referring to Historical Film	Total Responding (n=18)	Response (in Months)					
		<3	3-6	6-12	12-18	>18	N/A
After how much time is a film no longer referred to in the patient care process?	4(22.2%)	0 (0.0)	0 (0.0)	1 (25.0)	0 (0.0)	3 (75.0)	14

N/A = no response or not applicable

Note: 7 respondents (38.9%) indicated it was depended on the clinical context

Table 10
Hospital Sites Worked in: Radiology Technologists

Hospitals	Total Responding (n=18)	Hospitals
How many hospital sites do you work in?	16(88.9%)	1.1

Table 11
Hours Traveling Between Sites: Radiology Technologists

Function	Total Responding (n=18)	Average Time in Hours
Please estimate the number of hours per week you spend traveling between hospital sites?	4(22.2%)	0

Note: 4 respondents (22.2%) indicated it was non applicable; 14 others did not answer question

Table 12
Accessing of Film and Reports: Radiology Technologists

Where do you currently access film/reports?	Total Responding (n=18)	Yes Response
Medical Imaging		
Film	18(100.0%)	17 (94.4)
Reports	18(100.0%)	17 (94.4)
Private Office		
Film	18(100.0%)	0 (0.0)
Reports	18(100.0%)	0 (0.0)
Home Office		
Film	18(100.0%)	0 (0.0)
Reports	18(100.0%)	0 (0.0)

Table 13
Frequency of Accessing of Film and Reports: Radiology Technologists

Frequency of Accessing Film and Reports	Total Responding (n=18)	Response		
		Film	Reports	Both
What do you access most frequently?	18(100.0%)	3 (16.7)	2 (11.1)	13 (72.2)

Table 14
Perceived Benefits of PACS Pre-Implementation: Radiology Technologists

Perceived Benefit	Total Responding (n=18)	Response				
		Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
PACS will reduce the time locating exam to review	N/A	N/A	N/A	N/A	N/A	N/A
I will access exams more frequently with PACS than I do with film	N/A	N/A	N/A	N/A	N/A	N/A
I believe that report turnaround time will improve with PACS	16 (88.9%)	0 (0.0)	0 (0.0)	3 (18.8)	13 (81.3)	2
I believe that having access to PACS will improve the quality of the report	N/A	N/A	N/A	N/A	N/A	N/A
PACS will facilitate face to face consultation between myself and other radiologists	N/A	N/A	N/A	N/A	N/A	N/A
PACS will facilitate phone consultation between myself and other radiologists	N/A	N/A	N/A	N/A	N/A	N/A
My efficiency will improve because of PACS	N/A	N/A	N/A	N/A	N/A	N/A
PACS will improve my ability to make decisions regarding patient care	N/A	N/A	N/A	N/A	N/A	N/A
PACS will lead to a reduction in my patients' length of stay in hospital	N/A	N/A	N/A	N/A	N/A	N/A
PACS will reduce the number of patient transfers between facilities	N/A	N/A	N/A	N/A	N/A	N/A
PACS will reduce the number of exams reordered	N/A	N/A	N/A	N/A	N/A	N/A
PACS will enhance patient care and service delivery in rural Newfoundland and Labrador	17 (94.4%)	0 (0.0)	0 (0.0)	2 (11.8)	15 (88.2)	1

N/A = no response or not applicable

Table 15
Perceived Challenges with the PACS Pre-Implementation: Radiology Technologists

Perceived Challenge	Total Responding (N=18)	Response				
		Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
PACS will produce inadequate image quality on the Web	N/A	N/A	N/A	N/A	N/A	N/A
PACS will produce inadequate image quality on the workstation	14 (77.8%)	7 (50.0)	4 (28.6)	2 (14.3)	1 (7.1)	4
I will have difficulty finding images when needed	15 (83.3%)	7 (46.7)	7 (46.7)	1 (6.7)	0 (0.0)	3
I will experience inadequate Web performance (speed)	N/A	N/A	N/A	N/A	N/A	N/A
I will experience inadequate workstation performance (speed)	15 (83.3%)	4 (26.7)	8 (53.3)	3 (20.0)	0 (0.0)	3
I will have inadequate access to PACS viewing stations (PCs with Web or Workstations)	16 (88.9%)	0 (0.0)	7 (43.8)	7 (43.8)	2 (12.5)	2
I will have difficulty logging on to the system	16 (88.9%)	9 (56.3)	7 (43.8)	0 (0.0)	0 (0.0)	2
PACS downtime will be higher than acceptable	16 (88.9%)	6 (37.5)	8 (50.0)	2 (12.5)	0 (0.0)	2
I will receive insufficient training in the new technology	16 (88.9%)	3 (18.8)	9 (56.3)	4 (25.0)	0 (0.0)	2
I will be unable to view images at the patient's bedside	N/A	N/A	N/A	N/A	N/A	N/A
I will experience a lack of availability of system support	16 (88.9%)	5 (31.3)	7 (43.8)	4 (25.0)	0 (0.0)	2

N/A = no response or not applicable

Table 16
Demographics – Radiology Technologists

Demographic	Count (%)
Gender	
Male	5 (27.8)
Female	13 (72.2)
Total	18 (100.0%)
Years in Practice	
< 2	3 (17.6)
2 to 5	4 (23.5)
6 to 10	1 (5.9)
11 to 15	1 (5.9)
16 to 20	2 (11.8)
21 to 25	0 (0.0)
> 25	6 (35.3)
Total	17 (94.4%)
Number of Work Sites	
1	15 (93.7)
2	0 (0.0)
3	1 (6.3)
6	0 (0.0)
Total	16 (88.9%)

Table 17
Experience with PACS: Radiology Technologists

Have you had experience with PACS prior to this implementation project?	Total Responding (n=18)	Percent
Yes	4	22.2
No	14	77.8
Total	18(100.0%)	100.0%

Table 18
Radiology Technologist Specialty

Specialty	Total Responding (n=18)	Percent
Radiology Technician	2	11.1
Radiology Technologist	15	83.3
Other	1	5.6
Total	18(100.0%)	100.0%

Appendix L-8

Radiology Technologists: Post PACS Implementation
Terrier Health Authority
(n=28)

Table 1
Regional Health Authority

Regional Integrated Health Authority	Total Responding (N=43)	(n%)
Mastiff		
Spaniel		
Terrier	28	65.1

Table 2
PACS Experience

Have you had experience with PACS prior to this implementation project?	Total Responding (n=28)	n (%)
Yes	19	67.9
No	9	32.1

Table 3
PACS Experience (in Years)

How may years of PACS experience have you had?	Total Responding (n=28)	n (%)
<1	11	57.9
1-2	6	31.6
3-5	2	10.5
6-10	0	0.0
> 10	0	0.0
Total	19(67.9)	100.0
Mean	1.0	0.75
Median	1.0	
Range	2.7	

Table 4
Where Accessing PACS

Where do you access the PACS System?	**Total Responding (n=28)**	**n (%)**
Medical Imaging	28	100.0
Clinics/Units/Patient Care Floors	4	14.3
Private Office	0	0.0
Home	0	0.0

Table 5
Accessing Reports/Exams

What do you access most frequently?	**Total Responding (n=28)**	**n (%)**
Exams	8	28.6
Reports	0	0.0
Both	20	71.4
Total	28	100.0

Table 6
Perceived Benefits of PACS Post-Implementation: Radiology Technologists

Perceived Benefit	Total Responding (n=28)	Response				
		Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
PACS has reduced the time I spend locating exams for review	N/A	N/A	N/A	N/A	N/A	N/A
I access prior exams more frequently with PACS than I did with film.	N/A	N/A	N/A	N/A	N/A	N/A
I believe that report turnaround time has improve because of PACS (i.e. time to report dictated or time to preliminary report available)	27 (96.4%)	0 (0.0)	2 (7.4)	16 (59.3)	9 (33.3)	1
I believe that PACS tools and functionality improve the quality of my report	N/A	N/A	N/A	N/A	N/A	N/A
PACS has improved the quality and number of patient management rounds that I participate in	N/A	N/A	N/A	N/A	N/A	N/A
PACS has increased the number of face to face consultations I have with physicians and other radiologists	N/A	N/A	N/A	N/A	N/A	N/A
PACS has increased the number of phone (or other) consultations I have with physicians and other radiologists	N/A	N/A	N/A	N/A	N/A	N/A
PACS has reduced my professional travel time	N/A	N/A	N/A	N/A	N/A	N/A
PACS has improved medical student/radiology resident teaching	N/A	N/A	N/A	N/A	N/A	N/A
With the implementation of PACS, I report remotely for sites to which I previously traveled	N/A	N/A	N/A	N/A	N/A	N/A
With the implementation of PACS, I report remotely for new sites	N/A	N/A	N/A	N/A	N/A	N/A
PACS has improved my reporting and consultation efficiency	N/A	N/A	N/A	N/A	N/A	N/A
PACS has enhanced patient care and service delivery in rural Newfoundland and Labrador	25 (89.3%)	0 (0.0%)	0 (0.0%)	6 (24.0%)	19 (76.0%)	3

N/A = no response or not applicable

Table 7
Perceived Challenges of PACS Post-Implementation: Radiology Technologists

Perceived Benefit	Total Responding (n=28)	Response				
		Strongly Disagree	Moderately Disagree	Moderately Agree	Strongly Agree	N/A
PACS produces inadequate image quality on the remote Web (e.g. from home).	N/A	N/A	N/A	N/A	N/A	N/A
PACS produces inadequate image quality on the workstation	28 (100%)	21 (75.0)	7 (25.0)	0 (0.0)	0 (0.0)	0
PACS provides inadequate functionality on the remote Web	N/A	N/A	N/A	N/A	N/A	N/A
PACS produces inadequate functionality on the workstation	N/A	N/A	N/A	N/A	N/A	N/A
I have difficulty finding images in PACS when I need them	27 (96.4%)	19 (70.3)	6 (22.2)	2 (7.4)	0 (0.0)	1
I experience inadequate remote Web performance (speed)	N/A	N/A	N/A	N/A	N/A	N/A
I experience inadequate Workstation performance (speed)	28 (100%)	6 (21.4)	5 (17.9)	10 (35.7)	6 (21.4)	1
I experience inadequate access to PACS viewing stations	24 (96.4%)	10 (41.7)	12 (50.0)	2 (8.3)	0 (0.0)	4
I have difficulty logging on to the system	28 (100%)	22 (78.6)	4 (14.3)	2 (7.1)	0 (0.0)	0
PACS downtime is higher than acceptable	28 (100%)	8 (28.6)	17 (60.7)	3 (10.7)	0 (0.0)	0
I received insufficient training in the new technology	28 (100%)	14 (50.0)	12 (42.9)	1 (3.6)	1 (3.6)	0
I experience a lack of availability of system support	27 (96.4%)	13 (48.1)	11 (40.7)	3 (11.1)	0 (0.0)	1
The implementation /installation from film to PACS was well managed	28 (100%)	3 (10.7)	1 (3.6)	7 (25.0)	17 (60.7)	0

N/A = no response or not applicable

Appendix M

Report Turn-Around-Times (TAT) by Modality by Site
Terrier Health Authority

Appendix M

Report Turn-Around-Times (TAT) by Modality by Site
Terrier Health Authority

Hospital_A

Hospital_A is the largest hospital in the Terrier Health Authority having 186 acute care beds. The diagnostic imaging modalities for which TAT data was collected at Hospital_A were CAT scan (CT), echocardiography, magnetic resonance imaging (MRI), nuclear

medicine, general radiograph and ultrasound. Data was collected over the period September 2005 to December 2006 (N = 77,656).

<u>CAT Scan (CT)</u>

The total number of CT scans performed at Hospital_A from September 2005 to December 2006 was 9,831; average of 614 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 75.3, while the average TAT in hours for the 12 months post PACS implementation was 121.7 ($P<0.001$). The month that PACS was implemented (December 2005) was not included in the analysis.

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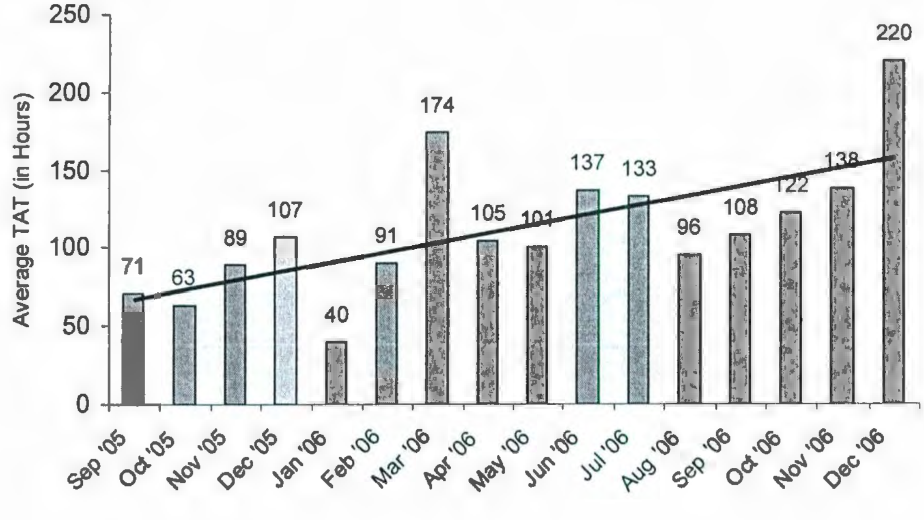
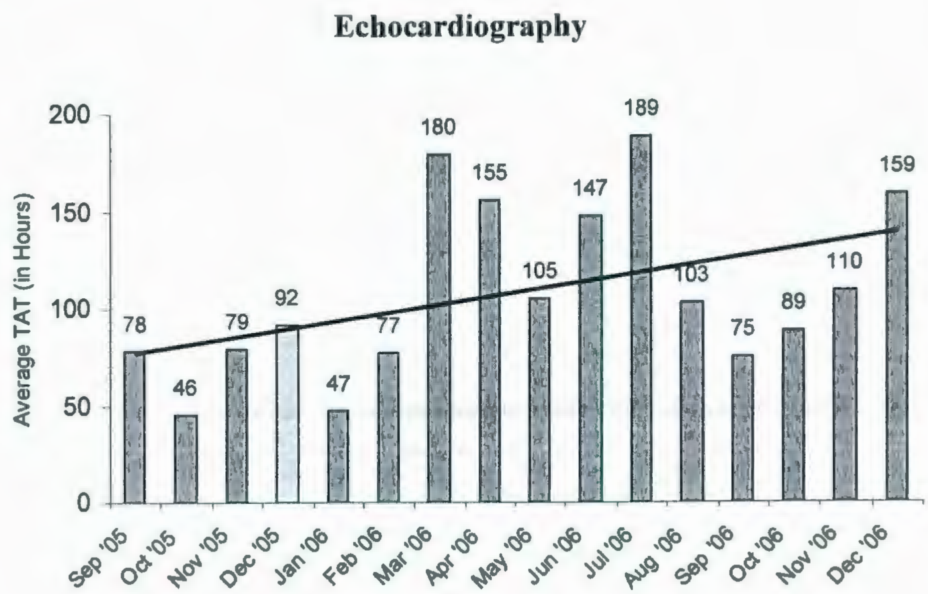
CAT Scan


Average TAT (in Hours)
250
200
150
100
50
0
71
63
89
107
40
91
174
105
101
137
133
96
108
122
138
220
Sep '05
Oct '05
Nov '05
Dec '05
Jan '06
Feb '06
Mar '06
Apr '06
May '06
Jun '06
Jul '06
Aug '06
Sep '06
Oct '06
Nov '06
Dec '06

Echocardiography

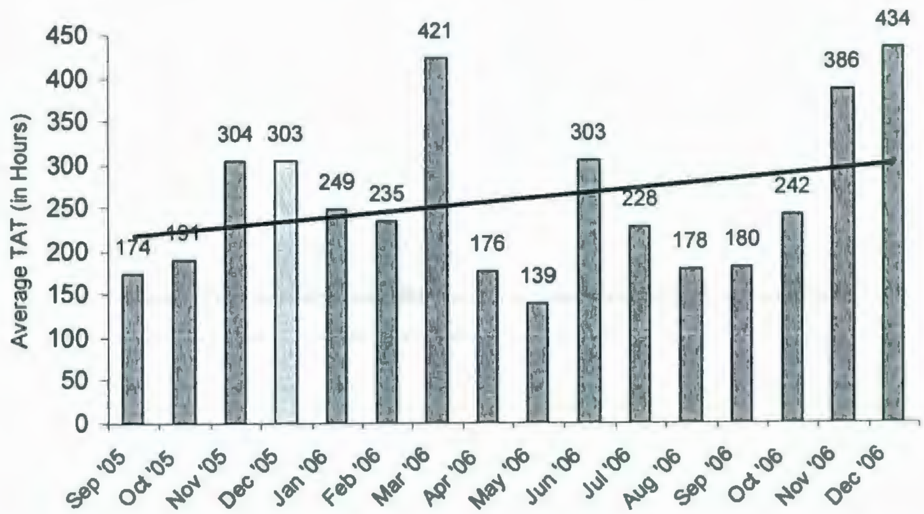
The total number of echocardiography exams performed at Hospital_A from September 2005 to December 2006 was 1,689; average of 106 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 68.1, while the average TAT in hours for the 12 months post PACS implementation was 123.4 (P<0.001). The month that PACS was implemented (December 2005) was not included in the analysis.



Magnetic Resonance Imaging (MRI)

The total number of MRI's performed at Hospital_A from September 2005 to December 2006 was 6,472; average of 405 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 217.6, while the average TAT in hours for the 12 months post PACS implementation was 265.5 ($P<0.001$). The month that PACS was implemented (December 2005) was not included in the analysis.

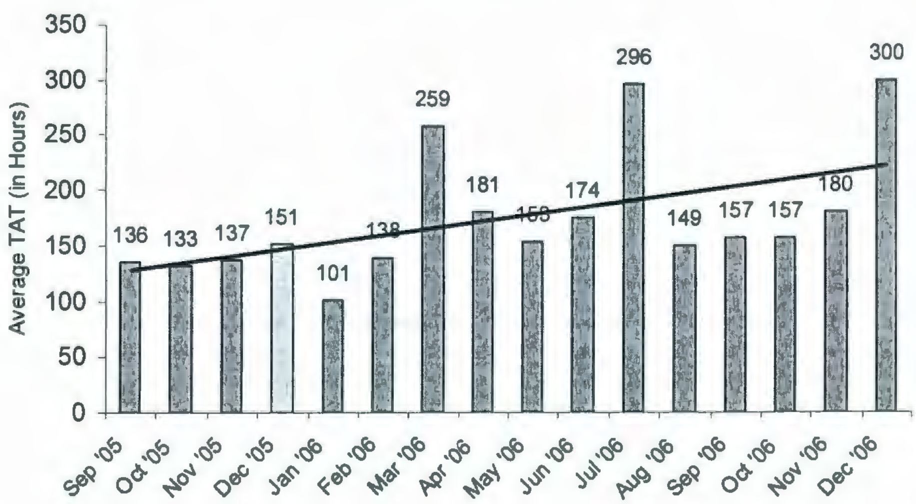
MRI



Nuclear Medicine

The total number of nuclear medicine exams performed at Hospital_A from September 2005 to December 2006 was 3,646; average of 228 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 135.6, while the average TAT in hours for the 12 months post PACS implementation was 185.9 ($P<0.001$). The month that PACS was implemented (December 2005) was not included in the analysis.

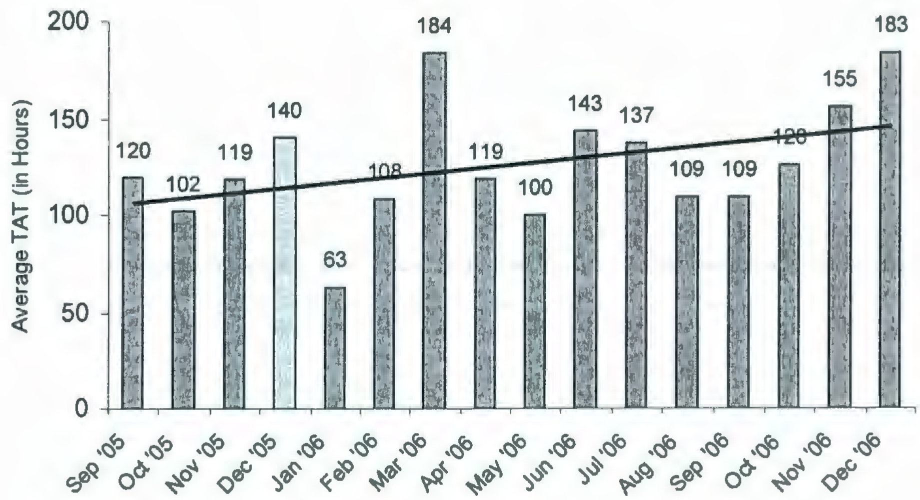
Nuclear Medicine



General Radiograph

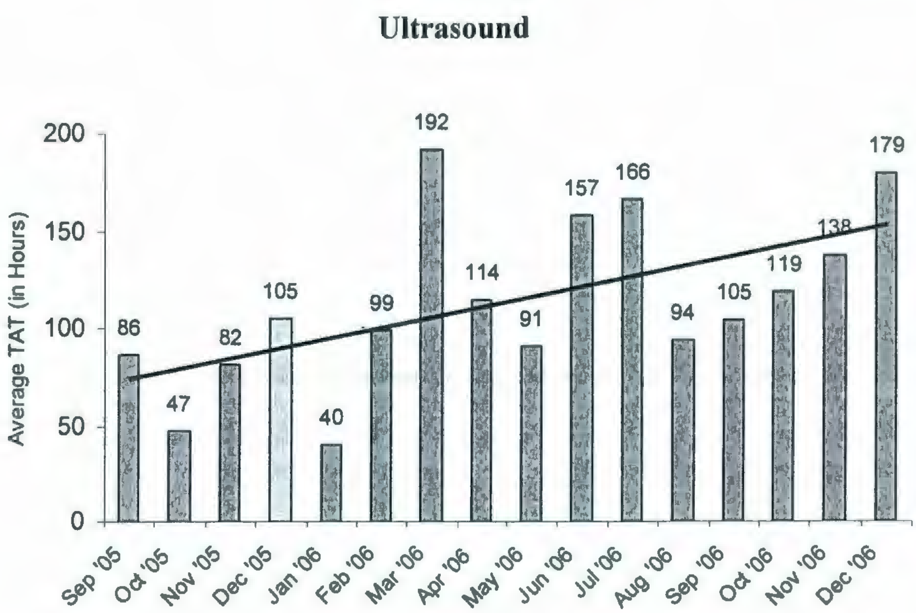
The total number of radiology exams performed at Hospital_A from September 2005 to December 2006 was 46,041; average of 2,878 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 114.0, while the average TAT in hours for the 12 months post PACS implementation was 125.9 ($P<0.001$). The month that PACS was implemented (December 2005) was not included in the analysis.

General Radiograph



Ultrasound

The total number of ultrasound exams performed at Hospital_A from September 2005 to December 2006 was 9,977; average of 624 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 73.3, while the average TAT in hours for the 12 months post PACS implementation was 124.6 (P<0.001). The month that PACS was implemented (December 2005) was not included in the analysis.



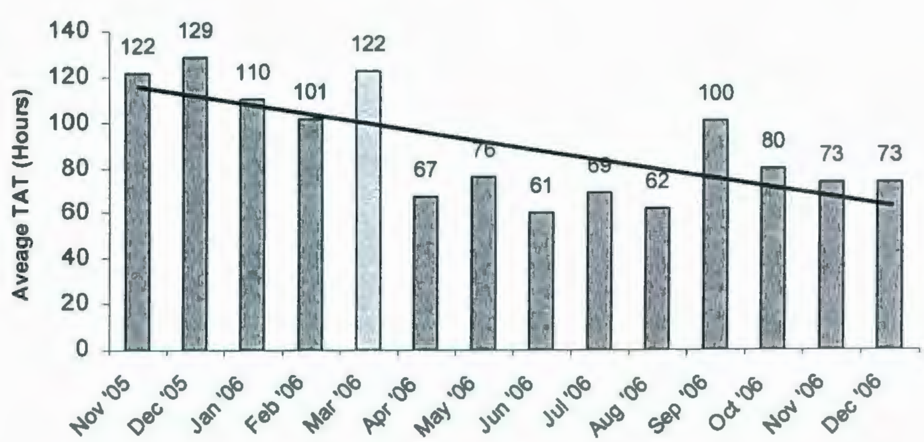
Hospital_B

Hospital_B is the second largest hospital in the Terrier Health Authority having 40 acute care beds. The diagnostic imaging modalities for which TAT data was collected at Hospital_B were general radiograph and ultrasound. Data was collected from November 2005 to December 2006 (N = 16,727).

General Radiograph

The total number of radiology exams performed at Hospital_B from November 2005 to December 2006 was 13,846; average of 989 per month. The average unverified report TAT in hours for the 4 months prior to PACS being implemented was 113.8, while the average TAT in hours for the 9 months post PACS implementation was 73.8 ($P<0.001$). The month that PACS was implemented (March 2006) was not included in the analysis.

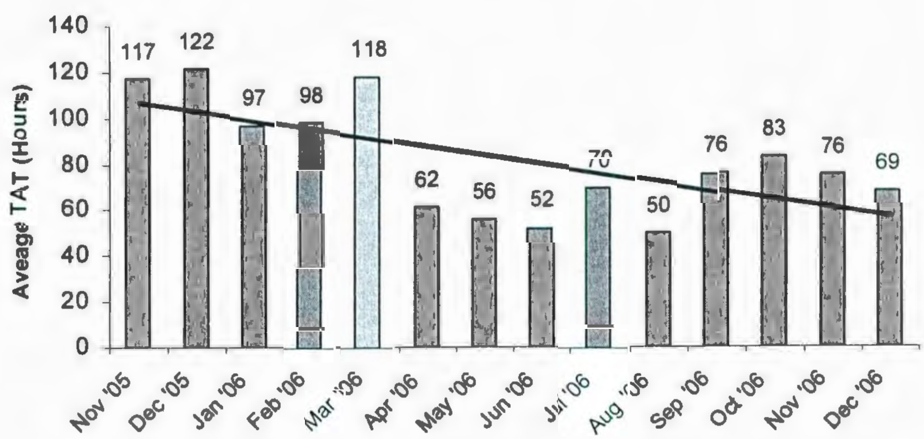
General Radiograph



Ultrasound

The total number of ultrasound exams performed at Hospital_B from November 2005 to December 2006 was 2,881; average of 206 per month. The average unverified report TAT in hours for the 4 months prior to PACS being implemented was 107.3, while the average TAT in hours for the 9 months post PACS implementation was 65.3 (P<0.001). The month that PACS was implemented (March 2006) was not included in the analysis.

Ultrasound

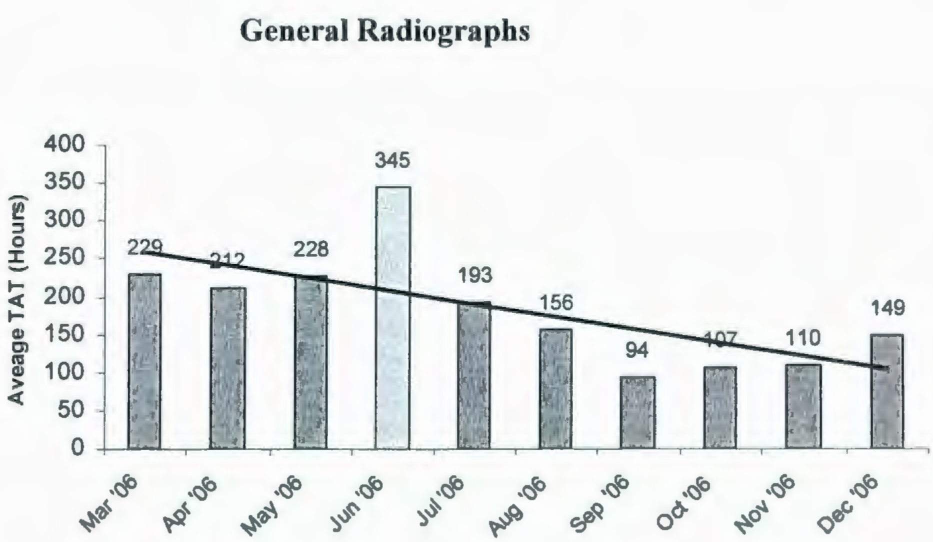


Hospital_C

The Hospital_C is the largest Health Centre in the Terrier Health Authority having 20 acute care beds. The diagnostic imaging modality for which TAT data was collected at the Hospital_C was general radiographs. Data was collected from March 2006 to December 2006 (N = 2,204).

General Radiographs

The total number of radiology exams performed at the Hospital_C from March 2006 to December 2006 was 2,204; average of 220 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 223.0, while the average TAT in hours for the 6 months post PACS implementation was 133.8 (P<0.001). The month that PACS was implemented (June 2006) was not included in the analysis.



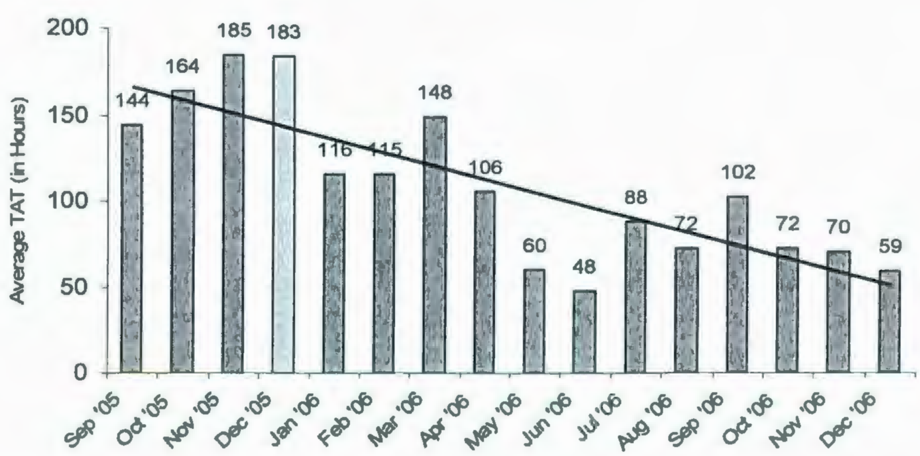
Hospital_D

Hospital_D is a medium size Health Centre in the Terrier Health Authority having 13 acute care beds. The diagnostic imaging modalities for which TAT data was collected at the Hospital_D was general radiographs and ultrasounds. Data was collected from September 2005 to Dec 2006 (N = 7,316).

General Radiographs

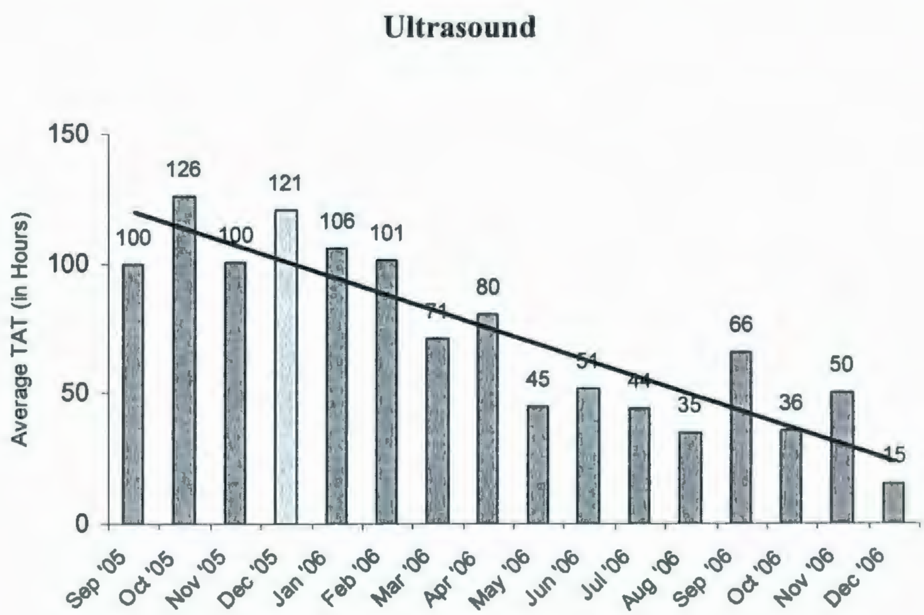
The total number of radiology exams performed at Hospital_D from September 2005 to December 2006 was 5,864; average of 367 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 152.0, while the average TAT in hours for the 12 months post PACS implementation was 72.0 (P = 0.03). The month that PACS was implemented (December 2005) was not included in the analysis.

General Radiographs



Ultrasound

The total number of ultrasound exams performed at Hospital_D from September 2005 to December 2006 was 1,452; average of 91 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 103.8, while the average TAT in hours for the 12 months post PACS implementation was 44.5 ($P<0.001$). The month that PACS was implemented (December 2005) was not included in the analysis.



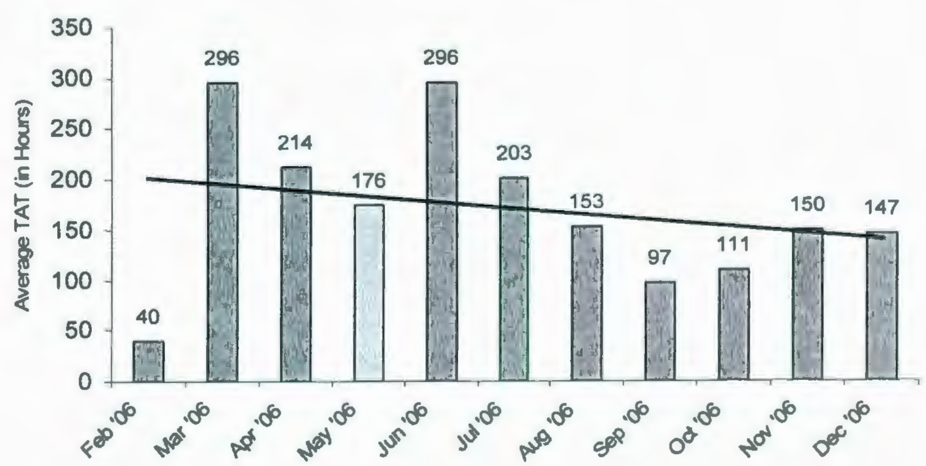
Hospital_E

Hospital_E is a small size Health Centre in the Terrier Health Authority having 6 acute care beds. The diagnostic imaging modalities for which TAT data was collected at Hospital_E was general radiographs. Data was collected from February 2006 to December 2006 (N = 1,667).

Radiology

The total number of radiology exams performed at Hospital_E from February 2006 to December 2006 was 1,667; average of 152 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 244.8, while the average TAT in hours for the 7 months post PACS implementation was 181.0 (P=0.02). The month that PACS was implemented (May 2006) was not included in the analysis.

General Radiographs



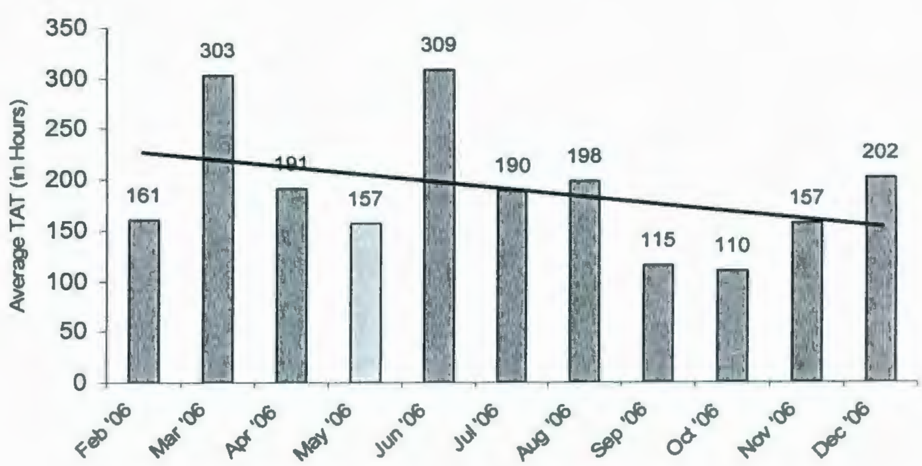
Hospital_F

Hospital_F is a small size health centre in the Terrier Health Authority having only one acute care bed. The diagnostic imaging modality for which TAT data was collected at Hospital_F was general radiographs. Data was collected from February 2006 to December 2006 (N = 1,134).

<u>General Radiographs</u>

The total number of radiology exams performed at Hospital_F from February 2006 to December 2006 was 1,134; average of 103 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 243.5, while the average TAT in hours for the 7 months post PACS implementation was 178.7 (P=0.03). The month that PACS was implemented (May 2006) was not included in the analysis.

General Radiographs



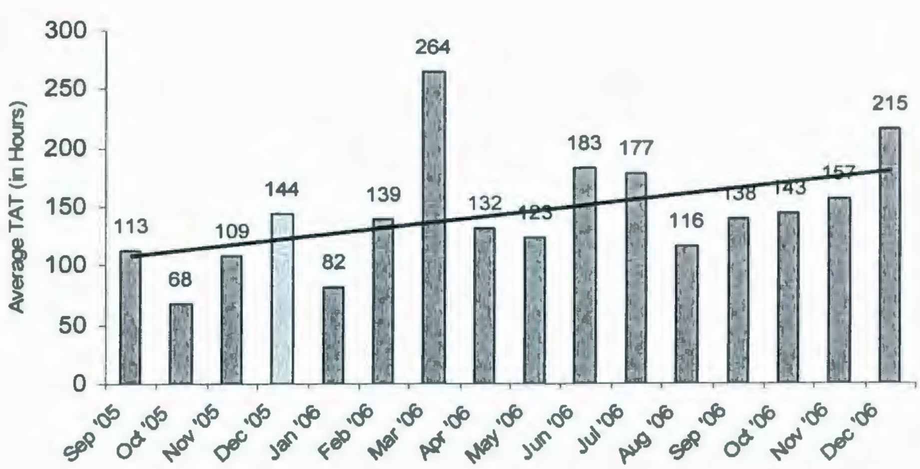
Hospital_G

Hospital_G is an out-patient clinic in the Terrier Health Authority. The diagnostic imaging modality for which TAT data was collected at Hospital_G was general radiographs. Data was collected from September 2005 to December 2006 (N = 5,963).

General Radiographs

The total number of radiology exams performed at Hospital_G from September 2005 to December 2006 was 5,963; average of 373 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 98.2, while the average TAT in hours for the 12 months post PACS implementation was 154.5 (P<0.001). The month that PACS was implemented (Dec 2005) was not included in the analysis.

General Radiographs



Appendix N

Report Turn-Around-Times (TAT) by Modality by Site
Mastiff Health Authority

Appendix N

Report Turn-Around-Times (TAT) by Modality by Site
Mastiff Health Authority

Hospital_H

Hospital_H is the main teaching hospital in the province, and is the largest hospital having 332 acute care beds. It is located in St. John's, the capital city. The diagnostic imaging modalities for which TAT data was collected at Hospital_H were CAT scan (CT), echocardiography, magnetic resonance imaging (MRI), nuclear medicine, general radiograph and ultrasound. Data was collected over the period June 2004 to June 2005 (N = 97,922).

CAT Scan (CT)

The total number of CT scans performed at the Hospital_H from June 2004 to June 2005 was 9,240; average of 770 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 88.4, while the average TAT in hours for the 9 months post PACS implementation was 67.4 (P<0.001). The month that PACS was implemented (September 2004) was not included in the analysis.

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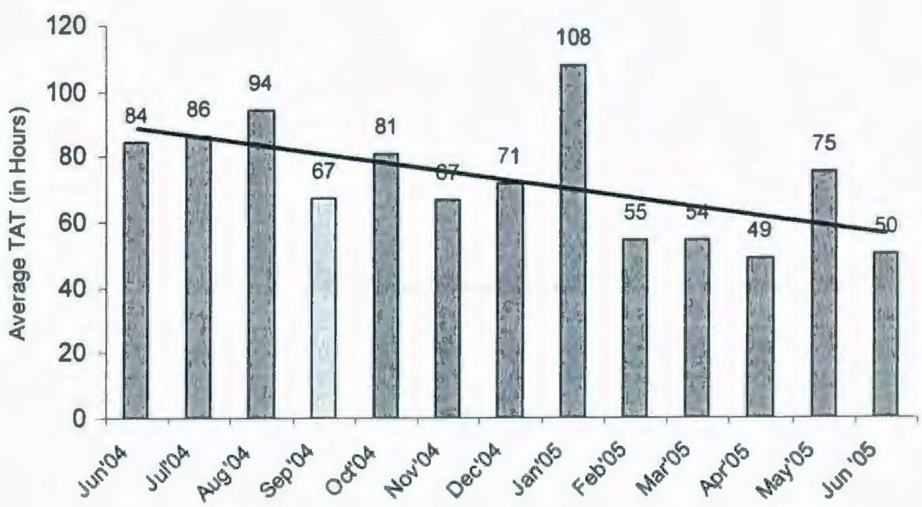
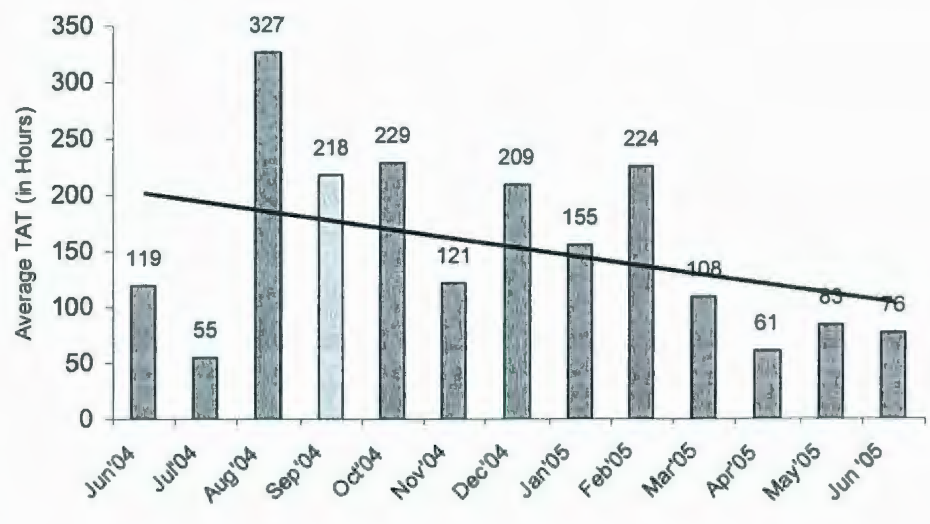
CAT Scan



Echocardiography

The total number of echocardiography exams performed at Hospital_H from June 2004 to June 2005 was 1,547; average of 129 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 175.4, while the average TAT in hours for the 9 months post PACS implementation was 135.0 ($P<0.001$). The month that PACS was implemented (September 2004) was not included in the analysis.

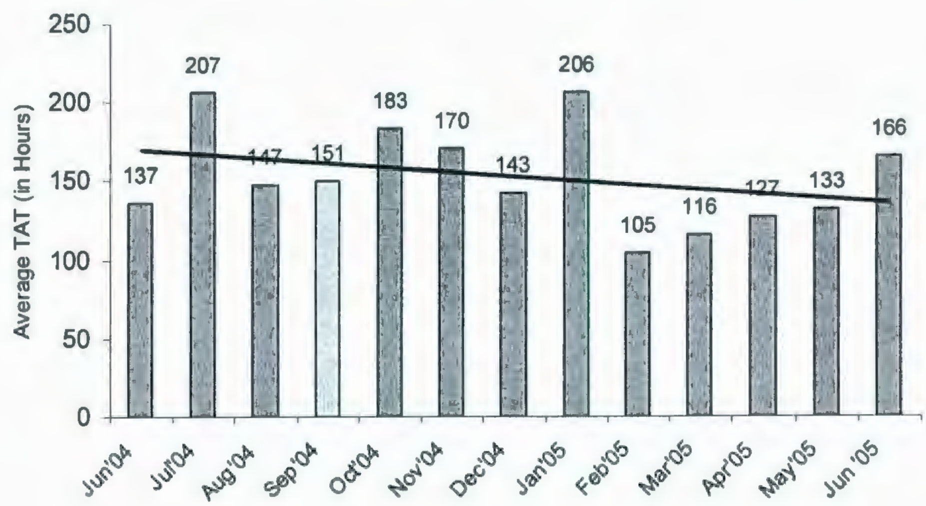
Echocardiography



Magnetic Resonance Imaging (MRI)

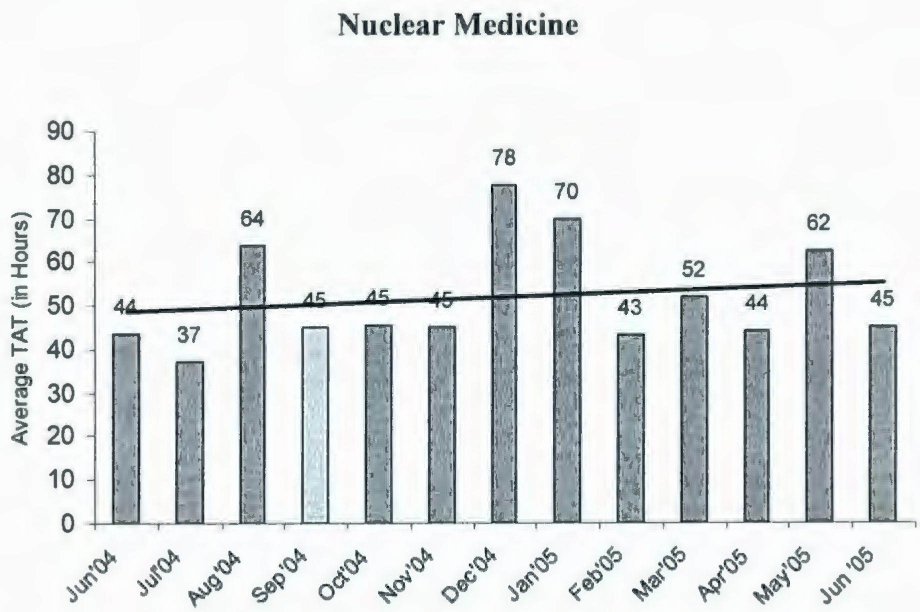
The total number of MRI exams performed at Hospital_H from June 2004 to June 2005 was 4,629; average of 386 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 165.5, while the average TAT in hours for the 9 months post PACS implementation was 149.4 (P = 0.02). The month that PACS was implemented (September 2004) was not included in the analysis.

Magnetic Resonance Imaging



Nuclear Medicine

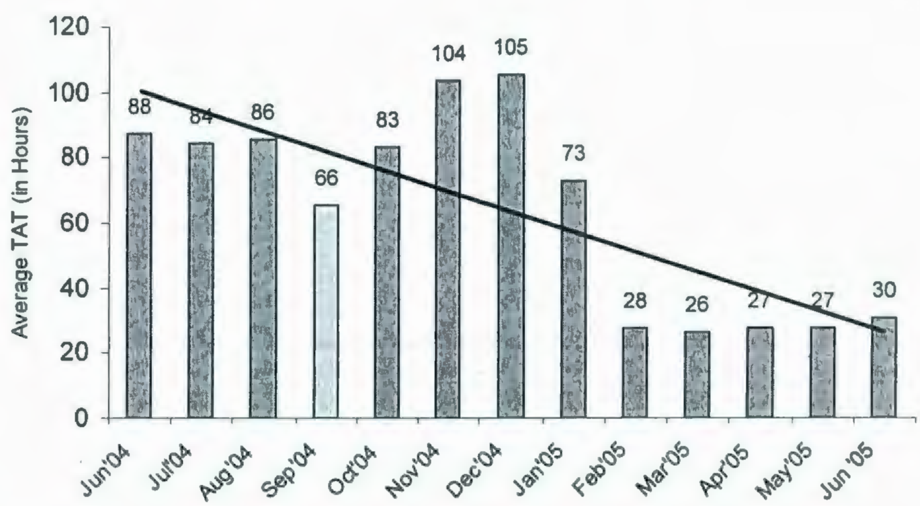
The total number of nuclear medicine exams performed at Hospital_H from June 2004 to June 2005 was 13,009; average of 1,084 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 48.4, while the average TAT in hours for the 9 months post PACS implementation was 53.9 ($P<0.001$). The month that PACS was implemented (September 2004) was not included in the analysis.



General Radiograph

The total number of general radiograph exams performed at the Hospital_H from June 2004 to June 2005 was 56,916; average of 4,743 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 85.8, while the average TAT in hours for the 9 months post PACS implementation was 57.4 (P<0.001). The month that PACS was implemented (September 2004) was not included in the analysis.

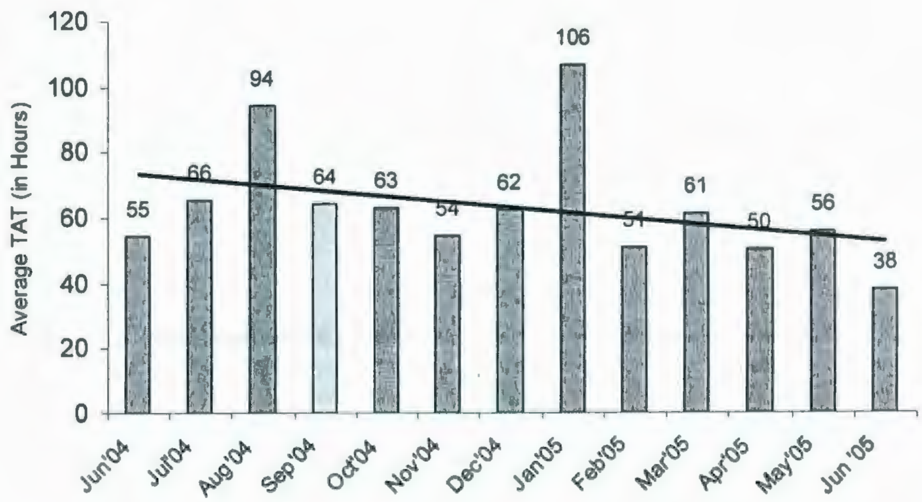
General Radiograph



Ultrasound

The total number of ultrasounds performed at Hospital_H from June 2004 to June 2005 was 12,581; average of 1,048 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 72.3, while the average TAT in hours for the 9 months post PACS implementation was 59.6 (P = 0.01). The month that PACS was implemented (September 2004) was not included in the analysis.

Ultrasound

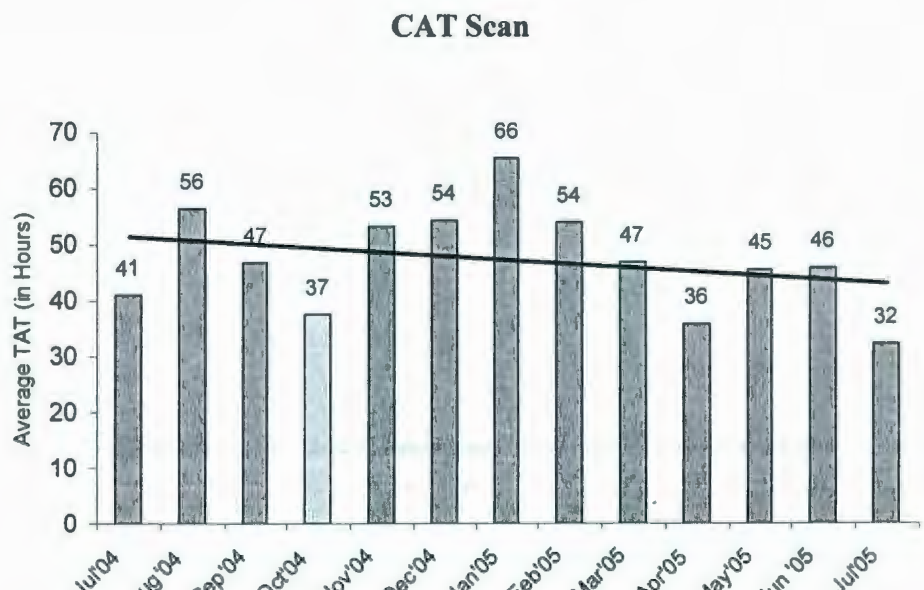


Hospital_I

Hospital_I is the second largest acute care hospital in the province of Newfoundland and Labrador having 208 acute care beds, and is located in the St. John's, the capital city. The diagnostic imaging modalities for which TAT data was collected at Hospital_I were CAT scan (CT), echocardiography, nuclear medicine, general radiograph and ultrasound. Data was collected over the period June 2004 to June 2005 (N = 73,428).

CAT Scan (CT)

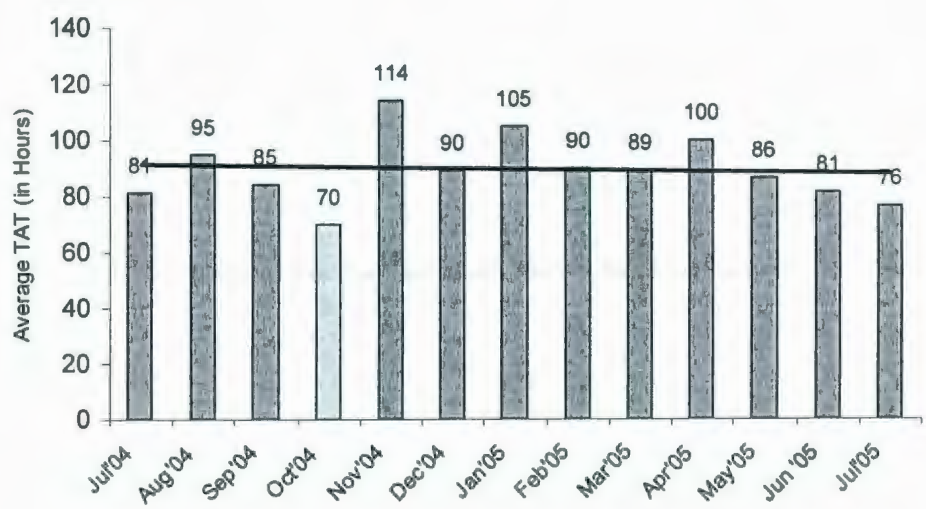
The total number of CT scans performed at Hospital_I from July 2004 to July 2005 was 9,215; average of 768 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 48.2, while the average TAT in hours for the 9 months post PACS implementation was 48.0 (P = 0.820). The month that PACS was implemented (October 2004) was not included in the analysis.



Echocardiography

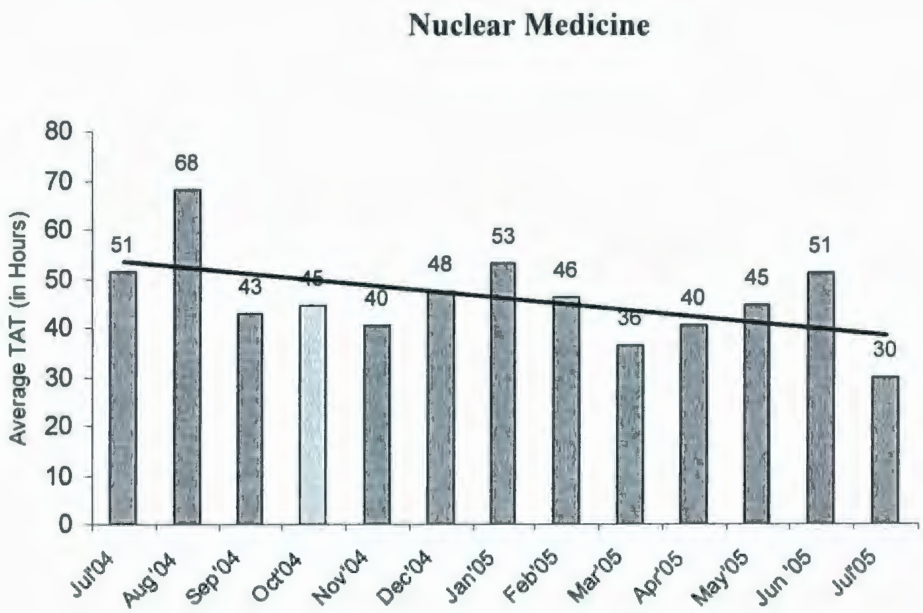
The total number of echocardiography exams performed at Hospital_I from July 2004 to July 2005 was 995; average of 83 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 87.2, while the average TAT in hours for the 9 months post PACS implementation was 93.5 (P = 0.068). The month that PACS was implemented (October 2004) was not included in the analysis.

Echocardiography



Nuclear Medicine

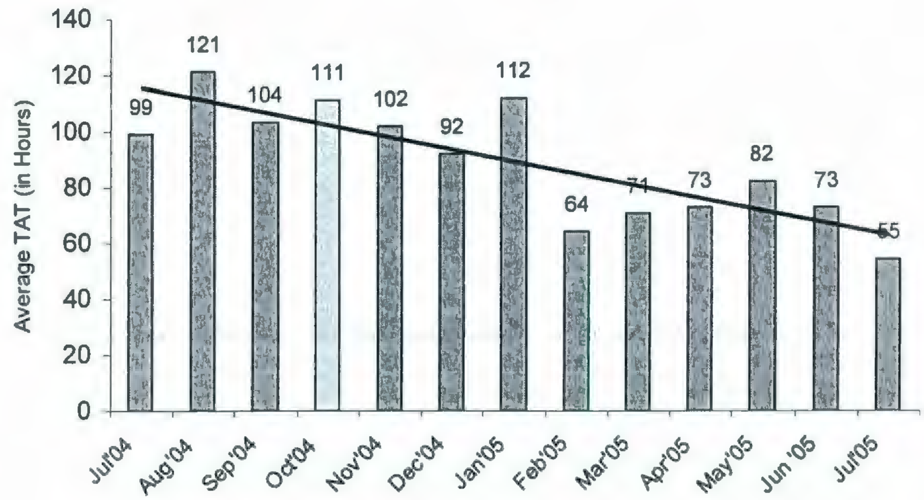
The total number of nuclear medicine exams performed at Hospital_I from July 2004 to July 2005 was 6,145; average of 512 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 54.2, while the average TAT in hours for the 9 months post PACS implementation was 43.7 ($P < 0.001$). The month that PACS was implemented (October 2004) was not included in the analysis



General Radiograph

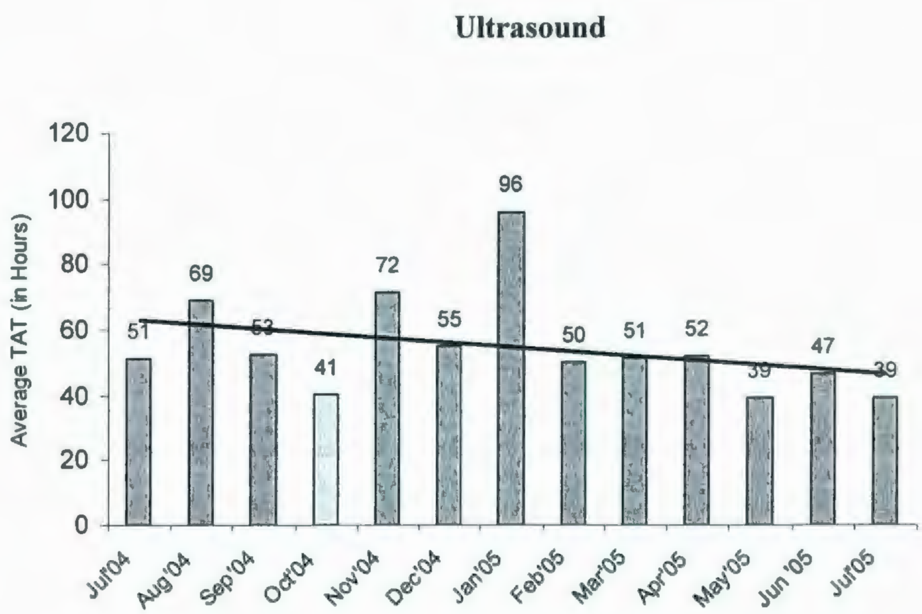
The total number of general radiograph exams performed at Hospital_I from July 2004 to July 2005 was 47,266; average of 3,939 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 107.4, while the average TAT in hours for the 9 months post PACS implementation was 81.3 ($P < 0.001$). The month that PACS was implemented (October 2004) was not included in the analysis.

General Radiograph



Ultrasound

The total number of ultrasounds performed at Hospital_I from July 2004 to July 2005 was 9,807; average of 817 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 57.4, while the average TAT in hours for the 9 months post PACS implementation was 55.5 (P = 0.11). The month that PACS was implemented (October 2004) was not included in the analysis.



Hospital_J

Hospital_J is the only designated psychiatric hospital in the province of Newfoundland and Labrador, having 94 acute care beds. It is located in the St. John's, the capital city. Hospital_J provides general radiograph services as an outpatient service to the general population. Data was collected over the period August 2004 to August 2005 (N = 6,505).

General Radiograph

The total number of general radiograph exams performed at Hospital_J from August 2004 to August 2005 was 6,505; average of 542 per month. The average unverified report TAT in hours for the 3 months prior to PACS being implemented was 138.1, while the average TAT in hours for the 9 months post PACS implementation was 114.2 ($P < 0.001$). The month that PACS was implemented (November 2004) was not included in the analysis.

General Radiograph