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The impact of an EMR on the management of adult patients with type two diabetes by family physicians in ruralnewfoundland

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ABSTRACT

PURPOSE This study was designed to determine whether the use of advanced features of an electronic medical record in a primary care setting could improve the process of delivering diabetes care in such a way as to produce improvements in diabetic outcome measures in adult type II diabetic patients.

METHODS The study was a Retrospective Cohort Study conducted in primary care clinics that had an established electronic medical record following 307 adult patients with type II diabetes over the course of two years. The clinics had similarly trained primary care physicians, similar patient populations, and used common diabetic care guidelines. The advanced EMR features used during the diabetic study included a diabetic template, premade laboratory requisitions, appeared consultations, flow sheets, and patient alerts. The dependent variables measured included the process of the delivery of diabetic care and the measurement of diabetic outcomes. The process of care measures were: the frequency of visits specific for diabetes care, ordering of HbA1c and LDL cholesterol, the measurement of blood pressure, and the documentation of these activities. The outcome measures included glycemic, lipid and blood pressure control as measured by HbA1c, LDL and blood pressure levels. The two independent variables of interest in the study were the extent to which the advanced features EMR are use by the physician and the second any changes noted in the outcome measures.

RESULTS The demographic information for the patients in this study was sex and age as well as baseline HbA1c, LDL, baseline systolic blood pressures, baseline diastolic blood pressures, and the number of visits that each patient had during the study period. The two groups were seen to be similar at baseline except for age and systolic blood pressure. The mean age of the intervention group was four years older than the control group and the comparison group had more people with systolic blood pressure at target. Age and systolic blood pressure were therefore controlled in the analysis. There was no difference in the two groups of patients in terms of measurements of HbA1c but there were differences in the frequency of measurements of LDL and blood pressures. Patients for whom the template was used during at least one clinical encounter, were 1.18 times more likely to have their LDL measured and 1.9 times more likely to have their blood pressure measured. Using logistics regression analysis there was a higher proportion of patients with an LDL at target in the intervention group.

CONCLUSIONS The meaningful use of EMRs in primary care, is possible through a process of maturity by design; an individualized approach looking at the needs of a given physician(s) and their practice(s) most likely to aid EMRs in achieving their potential. The technology needs to support care by automation of clinical processes and work flow behind the computer screen in such a way as to not disrupt or significantly change the patient physician interaction and focus both of these individuals on managing meaningful clinical outcomes personalized to each patient.

This document is a thesis submitted to *Schulich School of Medicine & Dentistry* in partial fulfillment of the requirements for Masters of Clinical Science (MClSc) and as such I am the sole author.

Dedication

This study was a meaningful use study designed to determine whether advanced features of an electronic medical record could be used to collect, store, measure, and report on the processes and outcomes of the delivery of diabetic care by individual primary care physicians. As such the study relied heavily on the technical expertise of a dedicated IT professional, Philip LeBlanc.

Unfortunately before this thesis could be completed Phil died and subsequently he did not have opportunity to see how all of his behind the scenes configuration of the EMR advanced our understanding of how this technology could improve the care of patients.

Thank you Philip for all you invaluable help on this project.

Acknowledgement

As with any significant endeavor the production of a thesis benefits from the assistance of a significant number of individuals. I would like to thank both of my supervisors, Drs. Moira Stewart and Marshall Godwin whose support and understanding during the entire process of designing research, executing it, and writing it up were invaluable. I would also like to recognize the assistance of two librarians, Lynn Dunikowski at Western University and Lindsay Alcock-Glenn at Memorial University whose assistance in searching the literature in a meaningful way was greatly appreciated. Finally I would like to thank my family for all of their support during not just the process of completing the thesis but the entire master's degree.

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List of Abbreviations

CBPHC   Community Based Primary Health Care
CDA   Canadian Diabetes Association
CDS   Clinical Decision Support System
CDM   Chronic Disease Management
CIHR   Canadian Institutes of Health Research
CPG   Clinical Practice Guideline
CPOE   Computerized Physician Order Entry System
EHR   Electronic Health Record
EMR   Electronic Medical Record
EPR   Electronic Patient Record
MCP   Medical Care Plan
MUN   Memorial University of Newfoundland and Labrador
NDSS   National Diabetes Surveillance System
NLMA   Newfoundland and Labrador Medical Association
OECD   Organization for Economic Co-Operation and Development
OPHC   Office of Primary Health Care
PHC   Primary Health Care
PHR   Personal Health Record
POSP   Physician Office System Program
PRISMA   Preferred Reporting Item for Systematic Review and Meta-Analysis

CHAPTER 1: Introduction

1.0 Overview of the chapter

Electronic medical records are computer-based patient records detailing patient demographics, medical and drug history, and diagnostic and laboratory information. They are described as being transformative in nature, with the potential to fundamentally change the work, productivity and processes in community-based practices thereby facilitating enhanced delivery of care. Chronic disease in general, and diabetes in particular present an ideal opportunity for the incorporation of health information technology into the provision of primary care medicine. The disease is highly prevalent in primary care populations, especially in Newfoundland and Labrador, is frequently associated with comorbid conditions, and requires multiple medications in its management. Additionally the effective care of a diabetic patient involves monitoring of several measures of disease control such as HbA1c and low-density lipoprotein levels as well as blood pressures. All of these factors combined to make diabetes an opportune disease state for the study of the implementation of health information technology in the management chronic disease conditions.

1.1 Introduction to the topic

Diabetes mellitus is a disease condition characterized by a disruption in glucose hemostasis that affects approximately 23 million people in Canada and the United States and accounts for approximately 105 billion dollars in annual health care costs.[1] Diabetic patients belong to one of two different disease classifications depending upon the underlying pathology. Type 1 diabetes, characterized by an absolute insulin deficiency, results from the

autoimmune destruction of the insulin-producing pancreatic beta cells, while Type 2

diabetes, results from in a relative deficiency in insulin due to both impaired insulin

secretion and resistance to its action, often secondary to obesity. Ninety to ninety-five

percent of patients with diabetes have type 2 diabetes. In addition to being a major risk

factor for cardiovascular disease, diabetes is also the primary cause of renal failure,

blindness and non-traumatic limb amputation worldwide.[2] This is in spite of the

availability of affordable and well-tolerated medications and the presence of evidence

based clinical guidelines on the management of the disease.

Attempts to disseminate clinical practice guidelines (CPGs) for the management of diabetes

have increased markedly in the past twenty years.[3] The motivation for this is the belief that

CPGs can improve the quality of care by: increasing the use of evidence-based therapeutics

to achieve identified targets; reducing harmful management strategies; and improving cost

effectiveness. [4]In spite of the wide spread dissemination, research suggests the guidelines

are not as widely adopted as their authors might have wished.[5] Cabana et al.[6] attempted to

determine why this is the case and reviewed 76 papers that investigated barriers to

physician use of CPGs. The authors identified 293 individual barriers, which they

subsequently divided into three broad groups: *Physician knowledge*, defined as a lack of

awareness of and familiarity with the CPGs; *Physician attitudes*, which included a lack of

agreement on specific guidelines, concern about whether the guidelines would work in

actual patient populations, and skepticism about implementing GPGs into their practice;

and *Factors external to the physician*, relating to the difficulty or complexity of the

guidelines, and a lack of resources for the implementation of the recommendations into their practices.

The majority of care for diabetics is provided in the community primary care practice setting. An environment characterized by short visits, competing visit objectives, issues around the management of multiple patient morbidities and medications, and patient and physician inertia related to the management of chronic disease conditions, it suffers also from an inadequate information structure.[7]

These are significant barriers to the management of diabetes, which are even more pronounced if an innovative approach to diabetes is applied to the management of the condition. In such an innovative paradigm the patient is not a passive recipient of medical ministrations but rather a part of a unit with the main provider serving as a resource coach and the patient as the principal driver of change. Regardless of which approach is taken in the treatment of type 2 diabetes information management is critical.

1.2 Literature on the effectiveness and impact of EMRs on Diabetes

1.2.1 Introduction

A literature review was conducted according to the methods provided by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) 2009 flow diagram.[8]

1.2.2 Background

Electronic medical records (EMRs) have been proposed as an effective health information management tool to improve diabetes care.[9] Proponents suggest the EMR can be used to identify patients with diabetes, assess if the patient is due any tests or screening procedures, and populate flow sheets used to track goals for glycemic, lipid and blood pressure control. Furthermore, EMRs have also been advanced as a means to improve the coordination of care among members of the health care team,[10] decrease the instance of incomplete clinical data,[11] and support evidence based clinical decision-making.[12] Movement towards wide-spread adoption of EMRs has been relatively slow with the 2013 National Physician Survey (NPS) showing exclusive use of EMRs by family physicians and general physicians at 64.3% and other specialists across Canada at 59.5%. Further research showed that 20 percent of users were only using basic EMR features such as patient data and prescribing[13] and only 4 to 6 percent of clinicians were utilizing full functionality for results management and clinical decision support.[14] [15]

Multiple uncontrolled studies have shown improvement in diabetes care temporally linked to EMR use, which may be over-stated given the general improvement in diabetes care over the past decade.[16] Controlled studies show limited positive impact on out-patient diabetes

care[17] with the principle improvement being in processes of diabetic care. Commercially developed EMRs do not seem to improve patient care in the primary care setting[18] while systems developed in-house over time improve adherence to clinical guidelines.[19] The research objective of this thesis is to determine if an EMR, configured with a locally developed diabetes profile and supported with clinical decision making tools, improves the management of patients as measured in terms of achieving three primary targets: blood pressure; HbA1c; and low density lipoprotein. The study is a before and after trial in which each physician's management of their diabetic patients is evaluated prior to and after the implementation of enhanced EMR features. The study involves seven family physicians in two clinics caring for over seven hundred diabetic patients.

1.2.3 Literature Search Strategy

A search strategy was formulated to answer the clinical question of the impact of an EMR on the management of adult patients with type-two diabetes by family physicians in a primary care setting. Particular attention was paid to randomized controlled trials, as these were most likely to provide valid information on the extent of the impact of the electronic interventions on the management of diabetes. Studies addressing the research question were identified through an electronic search of Pubmed/Medline, Embase, and Cinahl databases. The databases were searched by using a combination of database-specific subject headings (starting from the following Mesh Terms: computer or electronic or EMR and diabetes or diabetic and primary care or family medicine or family practice or therapy computer-assisted or electronic health records and diabetes, type /organization and administration or diabetes, type 2/prevention and control or diabetes, type

2/rehabilitation or diabetes mellitus, type 2/therapy and primary health care or family practice) and text-words for each domain in the search field.

Furthermore the search was expanded to include hand searches of the references related of the most relevant articles and the 2013 Diabetes Clinical Practice Guidelines.

The search was limited to English language publications from the last ten years and inclusion restricted to studies that described primary care physicians' use of electronic medical records in community practices to manage adult type 2 diabetic patients. The included studies looked at review articles, papers reporting on outcome measures and, research focused on both process and outcome measures.

1.2.4 Exclusion and Sorting

Papers were excluded if they did not describe the management of adult type 2 patients in primary care practices with electronic medical records. The initial screening was done by the author reviewing titles and abstracts and then examining the full-text versions of selected articles to further assess relevance of the research topic.

1.2.5 Findings

A total of three hundred and forty three studies were identified and the search strategy used to identify the relevant articles is depicted in figure form (Figure 1). A summary of the relevant articles is presents in table form. (Tables 1-3).
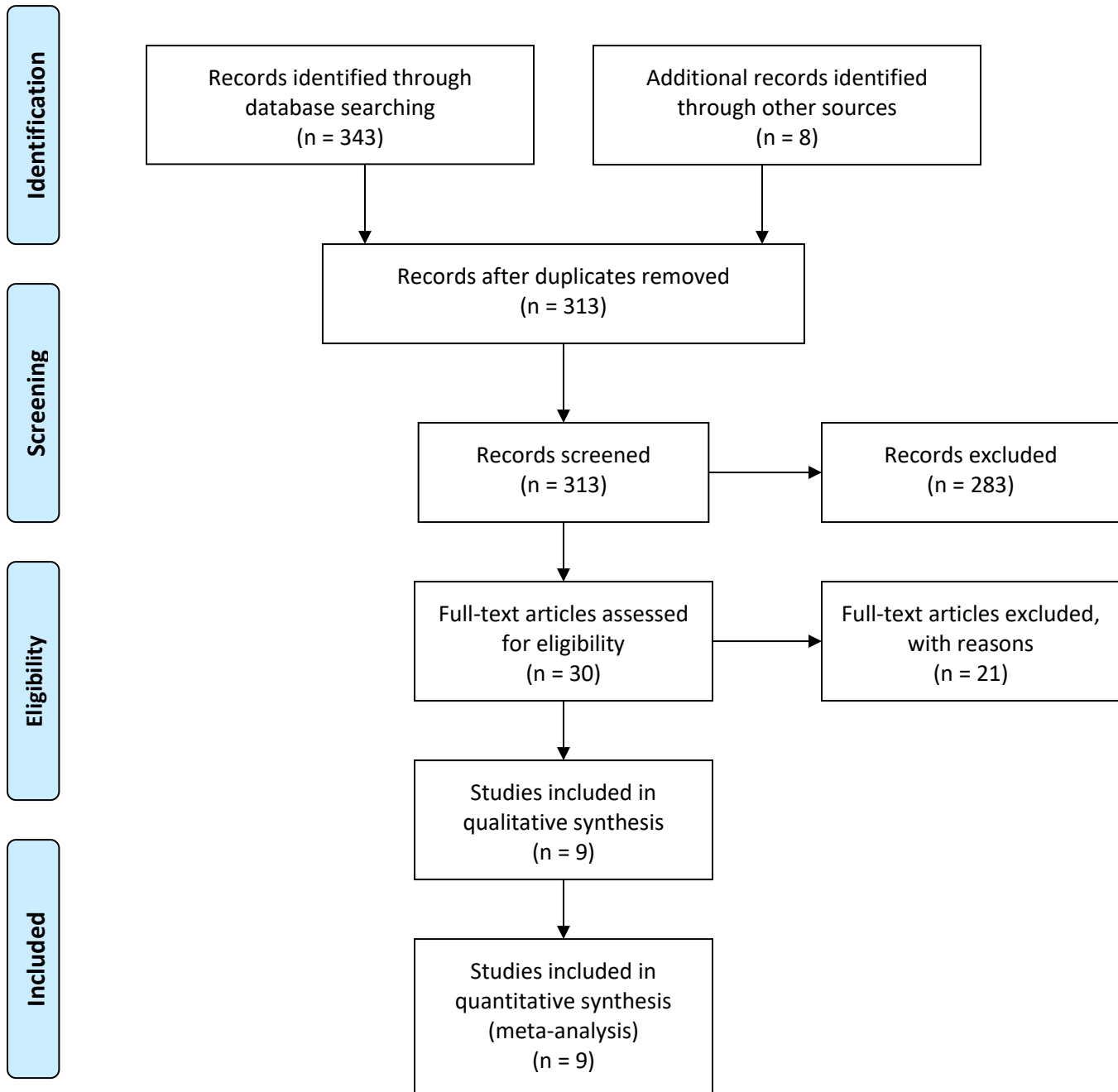
Figure 1: PRISMA 2009 Flow Diagram

Table 1: Summary of Relevant Review Articles

Title, Author, and Year	Type of Paper	Conclusions
A Proposal for Electronic Medical Records in U.S Primary Care. **Bates (2003)**	Position paper developed over four years by multiple organizations representing 300,000 primary care practitioners in the United States.	Electronic medical records provide many benefits, especially to primary care providers and given that such benefits are population wide they should be funded with public-private partnerships.
Information Technology for Clinical Guideline Implementation: Perceptions of Multidisciplinary Stakeholders. **Lyons (2004)**	Descriptive content analysis of 1,500 pages of focus group transcripts.	Administrators, physicians, and nurses hold different opinions about specific facilitators and barriers to information technology and clinical guideline use. Such disparate perceptions could undermine guideline initiatives.
Information Technology for the Treatment of Diabetes: Improving Outcomes and Controlling Costs. **Wyne (2008)**	Review article examining the practical applications of HIT for improving the delivery of care in diabetics	Implementation of information technology enabled diabetes management has demonstrated significant potential for improving processes of care, preventing development of diabetic complications, and generating cost savings. It improves the synthesis of information, the delivery of knowledge, and the efficacy of communication, allowing for coordination of care across teams. The diabetes registries show the most potential benefit for improving outcomes and reducing costs.
The use of information technology to enhance diabetes management in primary care: a literature review. **Adaji (2008)**	A literature review	Information technology can be used to improve diabetes care by promoting a productive and informative interaction between the patient and the care team.
How to Successfully Select and Implement Electronic Health Records in Small Ambulatory Practice Settings. **Lorenzi (2009)**	Review paper providing an overview from the literature of the perceived benefits and barriers to adopting HER into smaller practices.	The EMR implementation experience depends upon a variety of factors including the technology, training, leadership, the change management process, and the individual character of each ambulatory practice environment. Sound processes must support both technical and personnel-related organizational components.
Use of Health Information Technology to Advance Evidence-Based Care: Lessons from VA QUERI Program. **Hynes (2009)**	Document analysis of 86 implementation project abstracts followed up by semi-structured interviews with key informants from nine centres evaluated with qualitative and descriptive analysis.	Collaboration with multiple stakeholders is a key factor in successful use and development of HIT in implementation research efforts and in advancing evidence-bases practice.
Health Information Technology: Integration of Clinical Workflow into Meaningful Use of Electronic Health records. **Bowens (2010)**	Review of literature examining the role that clinical workflow plays on the successful implementation of HER in ambulatory care settings	The integration of EMR into clinical workflow will require a synergy between multiple approaches.
Electronic Health Records and Quality of Diabetes Care. **Cebul (2011)**	Retrospective cohort of primary care practices of seven diverse health care organizations that publically reported achievement of quality standards for adults with	Federal Policies encouraging the meaningful use of EHRs may improve the quality of diabetes care across insurance types.

	diabetes between July 2007 and June 2010.	
Qualitative Evaluation of a Diabetes Electronic Decision Support Tool: Views of Users. Wan (2012)	Qualitative study of telephone interviews of practitioners who had used an EDS tool for a minimum of six weeks. The transcripts were coded and thematically analyses using NVivo software.	The EDS tool showed promise as a way of summarizing information about patients' diabetes state, as a reminder of required diabetes care and an aide to patient education.

According to Wyne (2008), diabetes management enabled by health information technology has a significant potential for improving the process by which such care is delivered, thereby preventing the development of diabetic complications and generating system wide cost savings. In the literature review conducted by Adaji (2008), it was noted that information technology can improve productivity, and information interaction between the patient and the care team, but different opinions about specific facilitators and barriers to information technology adaption (identified by Lyons) among administrators, physicians, and nurses, suggests that this process may be problematic as a lack of collaboration between multiple stakeholders may lead to an unsuccessful HIT implementation. The success of an EMR implementation is dependent upon: the nature of the technology itself; the quality of training; the leadership within the group; the change management process; and the individual character of the practice in which the implementation is being undertaken (Lorenzi). Integrating the electronic medical record into the clinical workflow rather than structuring the delivery of care to fit the EMR is key to a successful implementation (Bowens) and tools that summarize information about an individual patient's diabetic state and remind the clinician of the requirement for diabetic care show promise in the management of these patients.

Table 2: Summary of Relevant Outcome Articles

Title, Author, and Year	Type of Paper	Conclusions
The Impact of Planned Care and a Diabetic Electronic Management System on Community-Based Diabetes Care. **Montori (2002)**	Before and after study comparing metabolic outcomes (including HbA1c, lipids and blood pressure values) over a twenty-four-month period in adult type two diabetics. Two hundred randomly selected patients were followed and a multivariable analysis used to estimate the association between planned care and a diabetes electronic management system.	Planned care was associated with improved performance and metabolic outcomes in diabetics in the primary care setting.

Table 3: Summary of the Process and Outcome Article

Title, Author, and Year	Type of Paper	Conclusions
Linking Guidelines to Electronic Health Records Design for Improved Chronic Disease Management. **Barretto (2003)**	A case study of guideline-compliant treatment of hypertension in diabetes with reference to the guideline algorithm from the Texas Diabetic Council	In the operation of an electronic chronic disease management system the information sourced from a common guideline must coordinate with the EMR content and should provide clear documentation of the clinical decisions taken.
Impact of an Electronic Medical record on Diabetes Quality of Care. **O'Connor (2005)**	Five year longitudinal study of 122 adult type two diabetics in an EMR clinic and a non-EMR clinic.	The EMR lead to an increased number of HbA1c and LDL tests but not to improved metabolic control.
Electronic Medical records and Diabetes Quality of Care: Results from a sample of Family Medicine Practices. **Crosson (2007)**	Cross-sectional analysis of baseline data from 50 practices participating in a practice improvement study between April 2003 and December 2004. A chart audit review a random sample of medical records for adherence to guidelines for diabetic processes of care, treatment, and achievement of intermediate outcomes.	The use of an EMR in primary care practices is insufficient for insuring high-quality diabetes care. Effort to expand EMR use should focus not only on improving technology but also on developing methods for implementing and integrating this technology into practice reality.
Electronic Medical records-Assisted Design of a Cluster-Randomized Trial to Improve Diabetes Care and Outcomes. **Love (2007)**	Clustered randomized trial of 12,675 patients comparing the effect of an EMR-facilitated disease management system against patient empowerment.	EMRs facilitated rigorous CRT design enables fair comparisons and can be replicated for other conditions enhancing the power of translational investigations.
Improving Diabetes Care in Practice Findings from the TRANSLATE Trial. **Peterson (2008)**	A group-randomized controlled clinical trial evaluating the practical effectiveness of a multicomponent intervention in 24 practices. The intervention included implementation of an electronic diabetic registry, visit reminders, and patient-specific physician alerts.	Introduction of a multicomponent organizational intervention in the primary care setting significantly increases the percentage of type two diabetic patients achieving the recommended clinical outcomes.
Individualized Electronic	A pragmatic randomized trial	A shared electronic decision-support

Decisions support and Reminders to Improve Diabetes Care in the Community: COMPLETE II Randomized Trial	involving adult type two diabetics who are assigned to regular care or an intervention wing with a web based color-coded diabetes tracker.	system to support the primary care of diabetes improves the process of care and some clinical markers of the quality of diabetes care.
Beyond Health Information Technology: Critical Factors Necessary for Effective Diabetes Disease Management. Ciemins (2009)	A pre/post intervention cohort analysis of 495 adult patients selected randomly and followed for six years. Two intervention phases were followed the first consisted of education and the second an EHR diabetes management period which included a diabetes registry and office workflow changes.	Implementation of a specialized EMR combined with tailored office workflow process changes was associated with increased adherence to ADA guidelines.
Impact of Electronic Health Record Clinical Decision Support on Diabetes Care: A Randomized Trial. O'Connor (2011)	**A clinical-randomized trial conducted from October 2006 to May 2007 of 2,556 patients in 11 clinics and 41 primary care physicians. Patients were randomized to either receive or not receive an EHR based clinical decision support system to improve care for patients whose biochemical markers were not at target during any office visit.**	**EHR-based diabetes clinical decisions support significantly improved glucose control and some aspects of blood pressure control in adults with type two diabetes.**
Typical Electronic Health Record Use in Primary Care Practices and the Quality of Diabetes Care. Crosson (2012)	Group-randomized quality improvement trial with 798 patients, which used hierarchical linear models to examine the relationship between EHR use adherence to evidence-based diabetes, care guidelines, and hierarchical logistic models to compare rates of improvement over three years.	Consistent use of an EHR over three years does not ensure successful use for improving the quality of diabetes care.

The use of an EMR in primary care practices even over a significant period of time is insufficient on its own to ensure high-quality diabetic care (Crosson) and may simply lead to the ordering of an increased number of hemoglobin A-1C and LDL tests with no measurable improvement in metabolic control (O'Connor). Increased adherence with the diabetic guidelines are seen when fully functional and specialized EMRs are combined with office workflow process changes (Ciemins) and multicomponent organizational intervention in primary care clinics increase the percentage of type II diabetic patients at the recommended clinical outcomes (Peterson).

1.3 Literature on Health Information Technology (HIT) in the Management of Adult Type Two Diabetics by Family Physicians in Primary Care

1.3.1 What is HIT

Over the last twenty years primary care has been advanced as both an orientating philosophy for the provision of community based medical services and as an actionable strategy for promoting and protecting the health of individuals in a cost effective manner. A study performed by Macinko and colleagues, which examined the impact of primary care systems in eighteen OECD countries from 1970-1998, demonstrated that nations with strong primary care systems had lower all-cause mortality, lower all-cause premature mortality and, lower all-cause mortality from selected chronic diseases.[20] In the United States of America the supply of primary care physicians has been showed to be associated with better health outcomes which include: lower all-cause mortality[21]; lower rates of cancer, heart disease and infant mortality[22]; and longer life expectancy[23]. The United Kingdom showed higher numbers of primary care physicians are associated with better self-reported health[24] and less obesity[25]. While Canadian studies have demonstrated how a larger supply of family physicians has been associated with earlier detection of breast cancer[26], more recommended newborn and preventive care visits for children,[27] and improved population health outcomes at a provincial level.[28]

Primary care was defined by the American Institute for Medicine in the late nineties as, "the provision of integrated, accessible health care services by clinicians accountable for addressing most personal health care needs, as developing a sustained partnership with patients, and practicing in the context of family and community."[29] This mirrored the definition advanced by Barbara Starfield that primary care is "that level of a health care service system that provides entry into the system for all new needs and problems, provides person-focused (not disease-

orientated) care over time, provides care for all but very uncommon or unusual conditions, and co-ordinates or integrates care provided elsewhere by others".[30] The Canadian Institutes for Health Research (CIHR) has championed the term "community-based primary health care" (CBPHC) as a " broad range of primary prevention and primary care services within the community, including health promotion and disease prevention; the diagnosis, treatment and management of chronic and episodic illness; rehabilitation support; and end of life care."[31] From 2000 to 2006 the province of Newfoundland and Labrador received 9.7 million dollars from the Federal government to aid in primary health care renewal. Funding was used, in part, to create networks of nine primary health care teams in order to provide a continuum of services including the treatment and management of chronic diseases. With the end of Federal funding in 2006, and the province's decision not to continue funding, the office of Primary Health Care closed. According to a report from the Auditor General of Newfoundland and Labrador, "As a result (of the closure of the office of Primary Health Care) the Province has not progressed to the level at which it should be with regard to the management and control of chronic disease."[32] The report continues to state that the elimination of the office resulted meant that the Department of Health was no longer providing support for the diabetes visits flow sheet to primary care providers and that funding for the Provincial Chronic Disease Collaborative Database which collected and reported the data contained in these sheets also ceased. According to the auditor this means that the Canadian Diabetes Association's estimates of the burden of diabetes in Newfoundland and Labrador has not captured the true cost of the condition due to incomplete data. (Table 4).
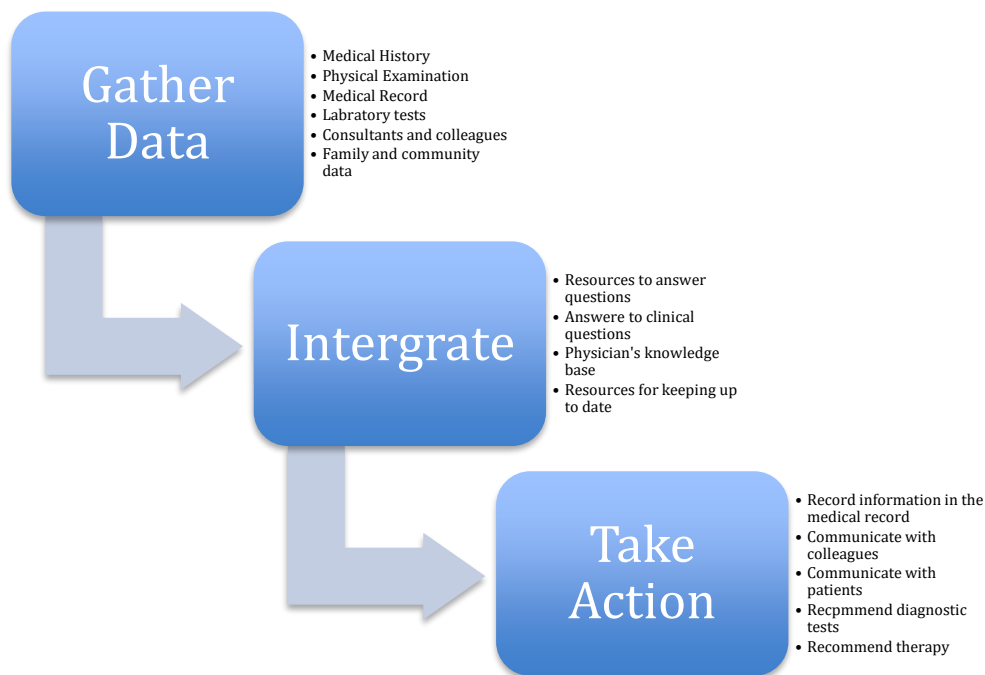
Table 4: The Burden of Diabetes in Newfoundland and Labrador

Key Statistics	2010	2020
Estimated diabetes prevalence (%)	9.3	14.4
Estimated number of people with diabetes	47,000	73,000
Estimated cost of diabetes	$254 million	$322 million
Estimated diabetes prevalence increase (%)	56% increase from 2010-2020	
Estimated cost increase (%)	27% increase from 2010-2020	

Central to the delivery of primary care is the family physician; who during the provision of care, manages information from a multitude of sources, integrates it into a system of biomedical knowledge, and decides in cooperation with patients on a therapeutic course of action. (Figure 2). Historically this has been accomplished with paper-based systems due to their ease of use, low cost and widespread acceptance. The challenge with a paper-based office is that data are stored in a passive format which prevents the automatic triggering of clinical decision support tools and impedes decision-making. This process becomes significantly more involved when the family physician is managing a chronic disease condition such as diabetes which has a high prevalence, is frequently associated with comorbid conditions, requires multiple medications, involves monitoring several biochemical markers, and intersects with multiple different providers. All of these factors make diabetes an opportune disease state for the implementation of health information technology (HIT).

Figure 2: The Flow of information in primary care adapted from Ebell and Frame[33]

Gather Data
- Medical History
- Physical Examination
- Medical Record
- Labratory tests
- Consultants and colleagues
- Family and community data

Intergrate
- Resources to answer questions
- Answere to clinical questions
- Physician's knowledge base
- Resources for keeping up to date

Take Action
- Record information in the medical record
- Communicate with colleagues
- Communicate with patients
- Recpmmend diagnostic tests
- Recommend therapy

HIT has been defined by the American Government Accountable Office (GAO) as "technology used to collect, store, retrieve, and transfer clinical, administrative, and financial health information electronically." In practical terms this technology is used to provide documentation in medical records, order labs and diagnostic imagery tests, generate prescriptions, schedule appointments and follow-up, billing, messaging, providing patient resources and analysis and reporting. HIT comprises a number of processes and systems with varying degrees of interoperability which include Electronic Health Records (EHRs), Electronic Medical Records (EMRs), Personal Health Records (PHRs), Computerized Physician Order Entry systems (CPOEs), Clinical Decision Support systems (CDS), and electronic prescribing systems (e-prescribing).

Advances in HIT provide the clinician with expert, timely, and meaningful data about patients and populations and have resulted in new opportunities for the design and delivery of healthcare. HIT has been used to create diabetic registries which providers can use to perform clinical audits.[34] Patients can track their blood glucose and blood pressures electronically download

those results into their computers and share them electronically with their primary care provider.[35] E-mail communications between patients, physicians and other care providers have facilitated interactive feedback based upon uploaded results and patients have been provided opportunity to view selected areas of their EMR all to produce better diabetic management.[36] [37]

The principle difference between HIT systems is the level of information sharing and the purported use for this information. An EHR is a secure and private lifetime record of health and care history available electronically to authorized health care providers.[38] In a Canadian context the EHR is to be operated by provincial governments as a higher-level system that pulls information from other systems such as EMR, PHR, and e-prescribing networks to allow for monitoring of health outcomes and provide a pan Canadian patient record. In contrast an EMR is a provider-centric tool that focuses on physician specific information. It is configured to reflect the needs of the individual physician or a group of physicians who are providing direct patient care and as such it will contain a record of every patient encounter.[39] The EMR has a central role in HIT as it is the principle system used by primary care providers and may interface directly with the EHR providing population based information or indirectly through other systems such as laboratory and diagnostic imagery ordering systems, pharmacy networks and provincial billing systems. The configurability of the EMR allows for the sequencing of activities during clinical encounters to improve the process by which care is delivered which is a perquisite to improving patient outcomes in chronic disease states.

1.3.2 Meaningful integration of electronic medical records into clinical workflow in the management of diabetic patients

The extent to which HIT is incorporated in a meaningful way into the management of the adult patient with type two diabetes can be conceptualizes in terms of both process measures and outcome measures. A process measure indicate how care was delivered and includes any diagnostic or therapeutic interventions while outcome measures are used to indicate the status of a patient at the end of an episode of care.[40] A literature review conducted in 2008 by *Adaji et al* [41] and published in *Informatics in Primary Care* identified 444 articles of which 29 were used in the paper (25 that satisfied the inclusion and exclusion criteria and 4 which were drawn from the references). Those authors found HIT lead to improved process measures such as increased ordering of tests for biochemical markers,[42] increased number of foot[43] and eye examinations[44], increased immunizations[45], and increased prescriptions for ACE inhibitors and Statins[46]. (Table 5)

Table 5: Impact on Process Mearues on Diabetic Care (Adapted by Adajj)

Process Measure	Clinical Decision Support (access to expertise)	Clinical Information System (access to data)	Delivery System Design (new design)	Self Management support (access to patient tools)
Foot check	Meigs (2003) Statistically significant improvement	East (2003) Statistically significant improvement Montori (2002) Statistically significant improvement Smith (1998) Statistically significant improvement		
Eye check	Meigs (2003) Non-statistically significant improvement Sequist (2005) No improvement	Montori (2002) Statistically significant improvement	Branger (1999) Non-statistically significant improvement	
Immunizations		East (2003) Statistically significant improvement Montori (2002) Statistically significant improvement		
Nutritional advise and change		Montori (2002) Statistically significant improvement		Glasgow (2003) Statistically significant improvement
Smoking cessation advise		Montori (2002) Statistically significant improvement		Glasgow (2003) Statistically significant improvement
Physical activity advise	Kim (2006) Statistically significant improvement	Montori (2002) Statistically significant improvement		McKay (2001) Non-statistically significant improvement Kim (2006) Statistically significant improvement
Medications	Sequist (2005) No improvement			

Outcome measures, specifically HbA1C and lipid levels, showed mixed results with some studies showing no improvement[47] while others showed statistically significant improvements.[48] (Table 6).

Table 6: Impact on Outcome Measures on Diabetic Care (Adapted by Adaj)

Outcome Measure	Clinical Decision Support (Access to expertise)	Clinical Information System (Access to data)	Delivery System Design (New design)	Self Management support (Access to patient tools)
HbA1c	Smith (2004) Statistically significant improvement Meigs (2003) No statistically significant improvement O'Connor (2005) No improvement Levetan (2002) Statistically significant improvement	Kim (2006) No statistically significant improvement	McMahon (2005) Statistically significant improvement Branger (1999) Statistically significant improvement Smith (2005) Statistically significant improvement	McMahon (2005) Statistically significant improvement Glasgow (2003) No statistically significant improvement Lee (2007) Statistically significant improvement Bond (2007) Statistically significant improvement Kwon (2004) Statistically significant improvement Kim (2006) No statistically significant improvement Harno (2006) Statistically significant improvement Smith (2005) Statistically significant improvement
LDL-cholesterol	Meigs (2003) Statistically significant improvement O'Connor (2005) No improvement		McMahon (2005) No improvement	McMahon (2005) No improvement Glasgow (2003) Statistically significant improvement Harno (2006) Statistically significant improvement
HDL-cholesterol			McMahon (2005) Statistically significant improvement	McMahon (2005) Statistically significant improvement Glasgow (2003) Bond (2007) Statistically significant improvement Kwon (2004) Statistically significant

			improvement
Total-Cholesterol			Glasgow (2003) Statistically significant improvement Lee (2007) Statistically significant improvement Bond (2007) Statistically significant improvement Harno (2006) Statistically significant improvement
Triglycerides		McMahon (2005) Statistically significant improvement	McMahon (2005) Statistically significant improvement Glasgow (2003) Statistically significant improvement Kwon (2004) Statistically significant improvement Harno (2006) Statistically significant improvement
Blood pressure	Meigs (2003) No improvement	McMahon (2005) Statistically significant improvement	McMahon (2005) Statistically significant improvement Bond (2007) Statistically significant improvement Harno (2006) Statistically significant improvement
Body weight			**Bond (2007) Statistically significant improvement**
Blood glucose	Lee (2007) Statistically significant improvement	Kim (2006) No statistically significant improvement	Lee (2007) Statistically significant improvement Kim (2006) No statistically significant improvement

The literature review by Adaji *et al* examined the impact from HIT systems which provided clinical decision support in the form of access to expertise, clinical information systems which provided patient data, delivery system designs which made changes to the means in which diabetes care was delivered, and self-management support which empowered patients with the information required to manage their diabetes. By the authors own admission their paper was limited in that there was considerable variability in the methods used in the studies and the papers considered were not scrutinized for methodological quality. That notwithstanding the findings suggest that HIT can improve patient self-management, enhance the delivery of diabetes care, and support clinical decision making with corresponding improvements in process and outcome measures.

The meaningful integration of an EMR into the clinical workflow of the primary care provider is a change management exercise and requires attention to the potential benefits and barriers of an EMR implementation. (Table 7)

Table 7: Potential Benefits and Barriers of EMR use in Diabetes Management[49]

Potential Benefits	Potential Barriers
Increased quality of healthcare	Initial cost
Reduction in medication errors	Physician resistance
Improvement in patient outcomes	Lack of funding
Reduction in health disparities	Fear of change
Cost savings	Privacy and security
Improved patient safety	Concerns of return on investment
Augmented chronic disease management	Lack of vision

While cost, funding, and concerns over return on investment (which includes physician time) are important to overcome, meaningful use of the EMR in diabetes management ultimately rests on

the removal of physician resistance.[50] Research has shown that physicians heavily weigh the potential effects of EMR on routine workflow.[51] (Table 8).

Table 8: Tasks Associated with Clinical Work-Flow[52]

Administrative Tasks	Clinical Tasks
Scheduling appointments	Medical treatment
Documenting patient information	Documentation of history
Accessing patient records	Examination and assessment of patient
Processing billing and claims	Develop treatment plan
communication	Patient education
	Prescription of medication
	Order entry
	Arrange referrals and clinic follow-up

As noted by Leu et al., "Understanding the full clinical context for HIT to the level of the task, resources, and workflow is a necessary prerequisite for successful adoption of HIT and measurement of its diffusion."[53] This is a complex task and consequently the movement to meaningful EMR implementation in the management of diabetes in the primary care setting has not been realized. In general terms an EMR implementation can be conceptualized as five step process requiring the physicians to, at each stage, identify and correct any issues that may impede workflow process issues before, during and after the implementation. (Figure 3)[54]

Figure 3: Phases of an EMR Implementation[55]

Phase 1
- Decision
- Process of identifying champions, gaining "buy-in", collecting information, understanding financial issuesand analyzing benefits.

Phase 2
- Selection
- Process of understanding both the practice needs and the capabilities of the EMR systems under consideration.

Phase 3
- Preimplementation
- Process of communicating with the involved parties to redesign workflows, establish a project plan and arrange for training.

Phase 4
- Implementation
- Process of making and managing change which involves radid implementation and extensive support

Phase 5
- Post implementation
- Process of continious updating, training, and evaluation

The post implementation phase is particularly important in relation to the meaningful use of the EMR. It is a process of maturation, after the initial shift in work flow, where physicians use EMR data in practice based population health management activities and/or use a specific bundle of EMR functionalities for chronic disease management. Functionalities which include the creation of patient registries for all diabetic patients, a systematic recall process for those patients, diabetes focused visits, clinical flow sheets to display key outcome measures in a longitudinal fashion to highlight trends, and links to expert management sites. According to the Alberta POSP Benefits Survey conducted in 2012, 86% of physicians enrolled in the Alberta EMR program reported that these functionalities improved their ability to manage patients with chronic diseases.

1.4 Summary

The implementation of information technology enabled diabetes management has demonstrated significant potential for improving the processes of care, preventing the development of diabetic

complications, and generating cost savings to the health care system. It has been seen to improve the synthesis of information, the delivery of knowledge, and the efficacy of communication; thereby allowing for coordination of care across teams. The physicians, nurses, and administers members of these teams hold different opinions about specific facilitators and barriers to information technology and clinical guideline use and such disparaging perceptions can undermine EMR initiatives. As such successful EMR implementation in guideline based chronic disease management depends upon a variety of factors including the technology, training, leadership, change management process, and the individual character of each ambulatory practice environment. Sound change management processes must support both technical and personal related organizational components. It is only through a multicomponent organizational intervention with repeated interventions that an EMR in the primary care setting can significant increase the percentage of type II diabetic patients achieving the recommended clinical outcomes.

The use of an EMR in primary care practices, an environment characterized by short visits, competing visit objectives, issues around the management of multiple patient morbidities and medications, and patient and physician inertia related to the management of chronic disease, is insufficient in and of itself for ensuring high-quality diabetes care. As such efforts to expand EMR use in diabetic management should focus not only on improving technology but also on developing methods for implementing and integrating this technology into practice reality. Steps as simple as using the EMR to produce diabetes registries show significant potential benefit for improving outcomes and reducing costs. Plan care, associated with improved performance and metabolic outcomes in diabetes in the primary care setting, is easier to deliver to identifiable patient populations. The EMR increase in the number of HbA1c and LDL tests ordered, but not

linked to improve metabolic control, can be mitigated by simple flow charts graphically representing trends in these values which support improved process of care by drawing the attention of both physician and patient to values that are not at desired target . Thereby facilitating decision-making in an individual patient's care plan to alter medications, improve clinical markers, and the quality of diabetic care.

CHAPTER 2: Development of the Intervention

2.0 Overview of the chapter

The quality of outpatient diabetic care falls short of evidence-based care recommendations[56], and various strategies have been suggested to improve diabetic care. EMRs have been proposed as a potentially effective information management tool for improving diabetes care[57], and an Institute of Medicine report has identified key features of EMRs that may lead to better care.[58] Current outpatient EMRs can be used to identify patients with diabetes, assess whether the patient is due for recommended tests or screening procedures, and determine whether the patient has or has not achieved evidence-based clinical goals for glycemic control, lipid control, and blood pressure control.

Current diabetes care, in the primary care setting, is characterized by high rates of clinical inertia, defined as a failure to intensify treatments in patients who have not achieved evidence-based clinical goals. Rates of clinical inertia in diabetes visits exceed 50%[59] and EMR technology seems well-suited to reducing this problem thereby improving care.

2.1 Burden of Diabetes

The expenditures for the Newfoundland and Labrador Department of Health and Community services for the 2010 fiscal year totaled $2.5 billion, which represented a $900 million dollar or 56% increase over the health costs for the fiscal year 2005.[60] While some of the increase can be attributed to the inflation relating to the cost of services and supplies, the bulk of the increase is a function of an ageing population and an increasing prevalence of chronic disease. The province has a significant issue with the prevalence of diabetes and the increasing health care costs

relating to diabetes as evident from information provided by the National Diabetes Surveillance

System (NDSS) and the Canadian Diabetes Association (CDA).

2.1.1 Prevalence of diabetes in Newfoundland and Labrador

According to these organizations Newfoundland and Labrador has the highest rate of diabetes of

any jurisdiction in Canada at 9.3% of the population in 2010, which cost the province $254

million. The NDSS calculate the prevalence of the condition and estimated health care costs

based upon the Medical Care Plan (MCP) figures from fee-for-service claims and hospital files

which does not capture the information from the salaried primary care physicians who constitute

a third of the physician work force. Additionally the statistics for the aboriginal peoples, a

population known to have increased incidence of diabetes, are also not tracked. Subsequently

the prevalence and cost of diabetes are understated.

2.1.2 Prevalence of diabetes in Central Newfoundland

Within the Central regional integrated healthcare authority, which serves a total population

94,104 people, the prevalence of diabetes is listed at 11%.[61] For the practices under study, which

provide primary health care services to 6475 patients, the number of patients listed as having

diabetes is 935 persons, which represents 14.4 % of the patient population.

2.2 Overview of EMR usage in Newfoundland and Labrador

The province of Newfoundland and Labrador is substantially behind other Canadian jurisdictions

in EMR use in part because it has no financial assistance or change management services for

physicians looking to implement EMRs into their practices. Provincial involvement in EMR

deployment has been limited to a pilot project completed in the Eastern Health Care Authority

almost a decade ago. The now defunct *Office of Primary Health Care* (OPHC) in partnership with

four other organizations {the *Newfoundland and Labrador Medical Association* (NLMA), the *Memorial University of Newfoundland Family Practice Unit* (MUNFPU), The Newfoundland Drive Medical Clinic, and *The Newfoundland and Labrador Centre for Health Information* (NLCHI)} collaborated on the production of this EMR demonstration project.

Funded by Canada Health Infoway and located within the Eastern Health Care Authority the demonstration project consisted of a four site EMR implementation conducted in the three academic family medicine clinics operated by MUN and one community clinic, which was also involved in teaching. [62] The number of strategic partners in the demonstration project has not been equaled in any subsequent EMR implementation and the legacy of this project had been to share lessons learned with physicians interested in an EMR through a peer-to-peer network. The success of that network was significantly limited by the absence of any financial support to EMR pioneers in the province and the formal peer-to-peer network has closed due to a discontinuation of its funding. The current number of EMR instillations around the province is a best guess and is listed in the following table (Table 9).

Table 9: EMR Installations in Newfoundland and Labrador

	Western RHA	Labrador-Grenfell RHA	Central RHA	Eastern RHA	Total
Practicing Physicians	129	53	146	724	1052
Using EMR	6	0	14	44	64
Wolf	0	0	0	27 (Demonstration site)	27
Nightingale	6	0	14	16	34
Other	0	0	0	1	1

2.3 Selection deployment and maturity of the EMR in Central Newfoundland

In July 2008 six family physicians from three separate clinics relocated their practices to a newly renovated facility complete with the largest privately funded electronic medical record implementation in the province of Newfoundland and Labrador and located in the Central Health Care Authority. The decision to transition from a paper-based system to an EMR was driven by practical space and staffing considerations and was informed by the work done with the provincial EMR demonstration project.

2.3.1 EMR Implementation

The Central Newfoundland EMR implementation was influenced by a number of factors including: the character of the technology; nature of training required to deploy it; organizational leadership; the change management process; and character of the practice environment.[63] The EMR demonstration project in Eastern Health was a larger practice setting implementation and the difference in scale between it and the Central Health experience is both real and important. The NLCHI was able to provide the Eastern Health demonstration project with a list of approved vendors whose set technical, data, and messaging standards that were consistent with the province's HIT vision. The presence of dedicated IT personnel in the collaborating health care

authority meant that an EMR solution with large servers installed in Eastern Health's data centre was possible. Involvement of multiple levels of leadership meant interfaces that accessed provincial laboratory and diagnostic were quickly provided. The change management process was overseen by a dedicated and trained team, the cost of the system was covered by an external agency and the bulk of the clinical practices were remunerated in such a way that clinical slowdowns had less of a finical impact. This is in contrast to the Central experience where the absence of funding, meaningful engagement by agencies (other than NLCHI) and the clinical volumes required a very different implementation strategy.

Generally, successful EMR implementation can be conceptualized as consisting of several phases: decision; selection; pre-implementation; implementation and post-implementation. Central to the implementation process is a structures approach to transitioning individuals and organizations from a current state to a desired future state.[64] Such a change management strategy is subjected to less resistance in smaller organizations as there is a tendency within such groups to seek steady state equilibrium.[65] This was the principal advantage of the Central Newfoundland EMR implementation. The driving vision behind the physician's decision to transition from paper charts to an EMR was to, improve patient care through more efficient access to electronic records leading to improve office efficiencies, was developed in a very short period of time. The close working relationships between the original group of physicians shortened the process of identifying champions and gaining "buy in" while the previous work done on the demonstration project meant that the collection of information on vendors, detailing of financial issues, analysis of work flows and understanding the benefits were completed in short order. Lessons learned by the NLCHI and communicated to the central physician group lead to an appreciation of the need to hire a dedicated IT professional during the pre-

implementation phase. In addition to providing technical expertise this position also had the responsibility to communicate with the physicians, office staff, and practice manager on the redesign of the workflow and conduct of training. The implementation phase was largely accomplished with the assistance of the vendor with ongoing support provided by the local dedicated support person.

2.3.2 EMR Selection

At the end of this process the electronic medical record selected was the Nightingale EMR. This product was chosen because of its perceived ease-of-use, ability to integrate clinical workflow, cost savings resulting from decreased office staff, scalability, and overall affordability. The EMR is an internet-based application service provider. The application architecture uses a 128 bit SSL encryption and off-site data storage for the secure storage of patient information. The EMR uses the JavaScript programming language with the Google Web toolkit, which is fairly standard for Internet-based products. HTML 5/CSS3 is the markup language employed by the Nightingale EMR to code for the formatting of the products layout.

2.3.3 EMR Maturity

The post implementation phase of the EMR in Central Newfoundland was largely limited to the support of basic EMR usage focused on recordkeeping and clinical processes. This differed considerably from the work that was done and continues to be done in jurisdiction such as Alberta, British Columbia, Manitoba and Ontario. A white paper prepared by Canada's Health Informatics Association titled *Canadian EMR Adoption and Maturity Model* summarized the EMR adoption models used in these four jurisdictions and produced a common Canadian EMR Adoption and Maturity Model which can be used to track the physician use of EMR to impact

clinical outcomes. The resultant common adoption model, suggested by the COACH's Canadian EMR adoption model, focused on three separate measures: functionality which includes the usefulness of tools for a particular clinical environment; breadth representing number of users, patients, and units, for a given product; and outcomes capturing improvements in patient health. (Figure 4).

Figure 4: Common Adoption Model
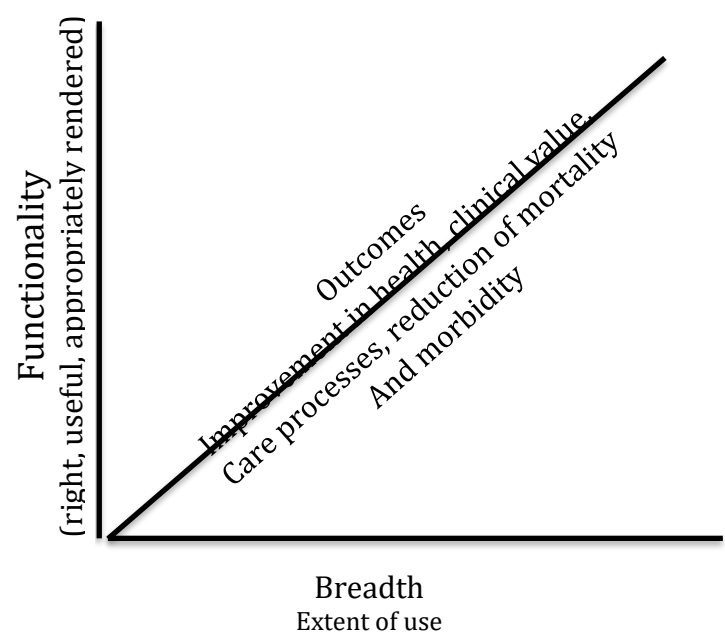
The white paper went on to build upon commonalities identified across the four jurisdictions to provide a six level model of EMR adoption and maturity. This model portrays the advancement of EMR maturity as physician's progress through the respective levels (Table 10).

Table 10: The Canadian EMR Adoption and Maturity Model

EMR Level progression	EMR Adoption Level	Description
Serial	**0** paper based	Paper is the dominant means of storing, accessing, and exchanging information
Serial	**1** basic electronic record keeping	EMR available with basic use for practice management streamlining of foundational clinical efficiency such as encounter documentation, prescription creation and renewal, lab ordering and scanning.
Serial	**2** clinical processes	Establishes clinical processes with decision-making support at the individual patient level, standardization of data coding and fully structured workflow practices.
Serial	**3** Advanced disease management	Enhanced delivery and support of care from automated clinical workflow and process including a focus on outcomes to manage complications and on advanced tracking for treatment adherence.
Iterative	**4** Integrated care	Supports adherence to optimal standards of care across and between care teams planning and reporting at the jurisdictional level through integration and exchange of information at the community and regional levels.
Iterative	**5** population impact	Profiles (based on risk or conditions) sub-populations; measures process and outcomes; provides performance feedback; supports regional health policy planning and reporting at the jurisdictional level.

2.4 Tool development

The Nightingale electronic medical record does have a chronic disease management module (CDM) that allows the product to be used to positively impact on entire populations of patients facilitating advanced disease management. In some jurisdictions diabetes management is guided by this CDM. Unfortunately the Nightingale implementation in the province of Newfoundland and Labrador is substantially smaller than in other jurisdictions and in the absence of a coordinated provincial EMR strategy the CDM functionality has not been engaged. As a result advanced disease management using this electronic medical record had to employ existing features

contained within the system to better organize the process of delivering diabetic care and attempt to improve outcome measures. A survey of the EMR usage by the seven physicians being studied indicated that they had some experience with the use of templates, premade laboratory requisitions, prepared consultations, flow sheets, and patient alerts. Subsequently each one of these functionalities was incorporated into the diabetic patient management tool, which constituted the intervention in this study, and was designed to improve the process of delivering diabetic care.

At the beginning of the study all of the patients with a diagnosis of diabetes identified by the ICD-9 code 0250 had a flowchart added to their cumulative patient profile. The purpose of the flowchart was to collect information from the diabetic clinical encounters and present that information in a meaningful way to allow the physician to track individual patient's HbA1c, LDL, and blood pressure values. The tool was developed so that the physicians began their clinical encounters in the usual manner. Once they opened a clinical encounter within the EMR they had opportunity to click on a profile button which allowed them to load a prepared diabetic visits note that automatically imported the diagnosis, prepared consultation letters, and clinical plan notes. During the clinical encounter the physicians had opportunity to use a template of care that guided the encounter and documented lab values, clinical examination, and education provided in a number of searchable fields that allowed for the tracking of care provided and populated the diabetic flow sheet.

2.5 Deployment of the IT solution

Upon completion of the configuration of all of the advanced EMR features to be used in the processes of delivering diabetic care in this study was completed, a six-month beta-test was conducted. During this period the diabetes management tool was used not by the IT personnel

who configured it but rather a clinician providing care to diabetic patients. Based upon the feedback some minor changes were made to the layout but no substantial changes to the tool were required. A seven page full-color double-sided professionally printed and bound "how to" manual was produced detailing an 11 point process to use all of the features of the study intervention (appendix 1). Each of the participating physicians was provided a copy of this documentation during a one hour one-on-one educational process with a dedicated and knowledgeable IT professional. Each physician was also made aware during these educational sessions that at any time should they have any questions on how to use the tool that the IT support personnel would be available to answer these questions. One month after the initial education session each physician was approached by the IT support personnel and offered an additional educational session.

2.6 Summary of the intervention

The intervention was characterized by the implementation of an advanced disease management tool to transform the provider's approach to managing diabetic patients in the family practice clinic setting. The EMR was customized to: identify all patients with diabetes; provide structured diabetic visit notes; prepared consultation letters; standardized laboratory requisitions; and populate diabetic flow sheets. The flow sheets were a key component to the intervention as they had been shown, in the past, to improve adherence to guidelines when it comes to assessing and treating diabetes.

CHAPTER 3: Evaluation of the Intervention

3.1 Introduction

This study was designed to determine whether the use of advanced features of an electronic medical record in a primary care setting improved the process of delivering diabetic care (frequency of visits, frequency of tests ordered, and documentation of critical results) and also produced improvements in diabetic outcome measures (HbA1c, low-density lipoprotein, and blood pressure values) in adult type two diabetic patients.

3.2 Setting

The study was conducted in primary care clinics that had established electronic medical records. The clinics were community-based and contained only family physicians with no on-site allied healthcare providers (regional diabetic clinics were available on a referral basis) and were teaching sites affiliated with the family medicine program of Memorial University of Newfoundland. Both of the EMR clinics were relatively small, with a stable staff of 3 to 4 physicians and were leaders in the province of Newfoundland and Labrador in the adoption and use of electronic medical records. The community in which the clinics were embedded was classified as rural in nature and demographically similar to many such centres within the province. The EMR in the study was an Internet-based application service provider (ASP) developed by Nightingale Informatics Corporation. The software itself is housed on a server located in Markham Ontario, and backed up on a server located in Calgary Alberta, and the clinic computers, which store no patient information, communicate with the servers over high-speed Internet. The Nightingale Corporation provided regular updates to the electronic medical record and on-site technical support was available in both the study clinics. The cost for the EMRs were born by the individual physicians who, in addition to an initial purchasing and startup fee, paid

monthly for continued access to the EMR. The EMR clinics also participated in other diabetes-related care improvement activities through their involvement with the Canadian Primary Care Sentinel and Surveillance network. This network, discussed elsewhere, provided information in the form of a report card to each clinician about the quality of the diabetic care that they were providing to their patients. Figure 5shows the timelines for the stages of EMR implementation just described.

Figure 5: Timeline for the Central EMR

Provincial EMR demonstration project
2007

Expansion to Martin Greenland
2012

Killick Clinics EMR implementation
2008

Diabetic EMR meaningful use projec
2013
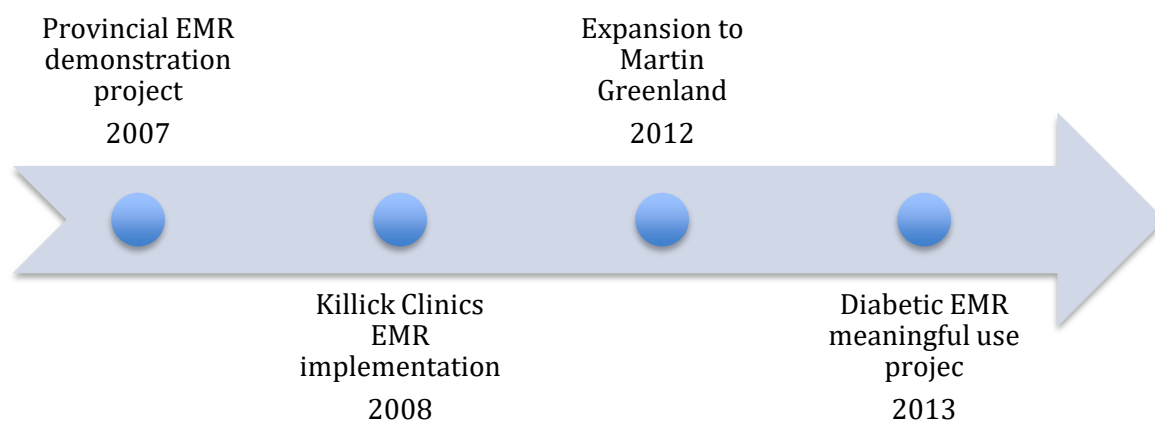
The clinics involved in the study were a relatively new entity, beginning in July 2008 when the physicians involved, transferred their practices from four separate offices into a new facility complete with the largest privately funded electronic medical record implementation in the province of Newfoundland and Labrador. The paper charts from the previous clinics were initially made available to the physicians for six-month period while they transitioned fully to the electronic medical record at which point the charts were then stored off-site. In 2012 the original clinic expanded to the point where was necessarily to open up a second clinic. Physicians typically consulted the EMR on a computer monitor located in each clinical examination room

with each patient visit. The EMR is used to generate the clinical encounter note in the SOAP format, order and manage pharmaceuticals, order and manage laboratory and diagnostic imaging requests, and to generate consultations. Due to challenges between the clinics and the Regional Integrated Healthcare Authority laboratory interface could not be established with the hospital-based meditec system and as a result the physicians involved in the studies have had to manage laboratory results outside of the electronic medical record. The advanced EMR features used during the diabetic study included a diabetic template, premade laboratory requisitions, prepared consultations, flow sheets, and patient alerts.

3.3 Selection of Participants

To evaluate the impact of the advanced EMR features on the process and outcomes of diabetic care, the study focused on all adults with an established diagnosis of diabetes. The potential pool of participants was drawn from all of those patients having been identified in the EMR, by provider, as having diabetes mellitus with an ICD-9 code of 250. Each physician's roster of diabetic patients was then reviewed with duplicate entries deleted to generate a list of possible patient participants that was then subject to a further evaluation. The electronic medical record of every patient rostered to the participating physicians, was reviewed to determine if they truly were a type II diabetic over 18 years of age who attended the clinic regularly. The ICD-9 250 code was routinely used by the participating physicians to identify those individuals who may possibly have diabetes and subsequently required further investigations, or those patients who had impaired fasting glucose or impaired glucose tolerance and required additional management with regards to cardiovascular risk factors, and also used to capture those individuals who experienced gestational diabetes. Subsequently it was required to review each patient record looking at the cumulative patient profile (CPP), medication list for diabetes specific drugs, clinical

notes for descriptions of diabetes, and laboratory requisitions or consultation notes, to determine if the patient was an actual type II diabetic or file or fell into one of the other categories. This methodology for the identification of diabetic patients was previously evaluated with an estimated sensitivity of 0.91 and a specificity of 0.99 with a positive predictive value of 0.94.[66]

A total of 935 patients out of a total patient population of 6475 were identified with the ICD-9 code of 250 and 625 of these were excluded as either being non-diabetic, having type I diabetes or gestational diabetes, or having not been see during the study or having died during the study period. As a result a total of 310 patients were included in the study.

3.4 Dependent variables

The two types of dependent variables measured included the process of the delivery of diabetic care and diabetic outcomes. The first type was process of care which was measured by the proportion of patients with the recommended number of tests performed in the year. The second type was the outcome of glycemic control as measured by HbA1C and lipid control (LDL) in addition to BP control. These were subsequently compared to the targets identified within the diabetes literature. Validity of the outcomes was enhanced by the following; all of the laboratory tests performed during the study were performed at a single accredited clinical chemistry laboratory managed and operated by a regional integrated healthcare authority.
The laboratory received its certificate of accreditation from the Institute for Quality Management and Healthcare based upon an assessment conducted from 12 February 2010 until 12 March 2010 and this ISO 15189 Plus accreditation was valid for the entire study period. The LDL was measured using a LDLD reagent in conjunction with SYNCHRON LX systems, UniCel DxC 600/800 systems, and SYNCHRON systems LDLD calibrator, to provide a direct qualitative determination

of low-density lipoprotein cholesterol in human serum. The HbA1c was calculated using a Tosoh Automated Glycohemoglobin Analyzers, which used a high-performance liquid chromatography assay to provide a qualitative measure of the percentage of HbA1c in whole blood specimens.

3.5 Independent Variables

There was one independent variable of interest in this study: the extent to which the physicians used the advanced diabetic patient management features of the EMR. This was measured by reviewing every clinical encounter for those patients identified as having diabetes during the study period to determine the number of diabetic visits in which the prepared diabetic care template was used. This was dichotomized to the patients for whom the template was used at least once versus not used ever.

3.6 Covariates

The covariates within the study include the patient's age and sex and these were obtained from the demographic component of the electronic medical record for each patient.

3.7 Plan of Analysis

The analysis was designed to test two hypotheses: (1) use of the tool is associated with the proportion of patients with the recommended number of tests performed in the year, and (2) use of the tool is associated with the change in values of HbA1c, LDL, and BP over time. Analysis conducted compared the two groups of patients at baseline and provides information about; Sex, baseline HbA1c, baseline LDL, baseline systolic blood pressure, baseline diastolic blood pressure, and number of visits during study period. Chi-squared was used to test for statistical significance.

To control for potential confounders (age, sex, number of visits) logistic regression was conducted for seven outcomes. Three process outcomes (HbA1c, LDL, and BP measured according to guidelines) and four physiological outcomes (HbA1c, LDL, systolic BP and diastolic BP achieved recommended targets). With an additional controlled variable being the baseline of the relevant outcome.

Logistic regression was conducted for each of the seven outcomes. For each of the three process outcomes (whether HbA1c, LDL, and BP was measured according to guidelines) the independent variables were Group (tool vs no tool), Age, Sex, and Number of Visits (More than 3 visits vs 3 or less).

For the target achievement outcomes (whether HbA1c, LDL, systolic BP and diastolic BP achieved recommended targets) the independent variables were Group (tool vs no tool), Age, Sex, Number of Visits (tool vs no tool), and the baseline level of HbA1c, LDL, or Blood Pressure, depending on the dependent variable.

3.8 Results

The purpose of this research project was to determine if the advanced features of an electronic medical record improve the processes by which primary care physicians delivered diabetic care in such a way as to improve clinical outcomes. The results are represented in the following tables. Table 11 contains a listing of the baseline characteristics and comparison variables between the groups of the patients under study. The two groups are seen to be similar at baseline except for age and systolic blood pressure. The mean age of the intervention group was four years older than the comparison group and the comparison group had more people with systolic blood pressure at target. These variables and others were controlled for using multivariate analysis.

Table 11: Baseline Characteristics and Other Group Comparison Variables

Variable		Total Population of Diabetic Patients N= 310	Patients for Whom the Template was Used as least Once. N=108	Patients for Whom the Template was Never Used N=202	P Value* (Template used vs Template not used)
Mean Age(Years) #(SD)		65.1 (SD: 11.5)	67.9 (SD: 10.1)	63.6 (SD: 11.9)	0.001
Sex #(%)	**Male**	157(50.6%)	54 (50%)	103 (51%)	0.963
	Female	153 (49.4%)	54 (50%)	99 (49%)	
Baseline A1c at Target #(%)	**Yes**	121 (39%)	37 (34.3%)	84 (43.5%)	0.147
	No	180(58.1%)	71 (65.7%)	109 (56.5%)	
	Missing	9 (2.9%)	0	9	
Baseline LDL at Target #(%)	**Yes**	155 (50%)	65 (62.5%)	90 (53.6%)	0.187
	No	117 (37.7%)	39 (37.5%)	78 (46.4%)	
	Missing	38 (12.3%)	4	34	
Baseline Systolic BP at Target # (%)	**Yes**	138 (44.5%)	42 (42.9%)	96 (60%)	0.011
	No	120 (38.7%)	56 (57.1%)	64 (40%)	
	Missing	52 (16.8%)	10	42	
Baseline Diastolic BP at Target # (%)	**Yes**	200 (64.5%)	76 (77.6%)	124 (77.5%)	0.999
	No	58 (18.7%)	22 (22.4%)	36 (22.5%)	
	Missing	52 (16.8%)	10	42	
Number of Visits during study period	**More Than 3**	112 (36.1%)	33 (30.6%)	79 (39.7%)	0.143
	3 or less	195 (62.9%)	75 (69.4%)	120 (60.3%)	
	Missing	**3 (1%)**	**0**	**3**	

* Based on available (non-missing) data, p value calculated using chi-squared test.

Table 12 is a comparison of both the processes of delivering diabetic care and the outcomes of that care between the patients who had the template used and those patients who did not have the tool used during their clinical encounters. From this table some differences in the process of delivering care can be seen. Although there were no differences in the two groups in terms of the measurement of HbA1c there were some differences in the frequency of the measurement of LDL and blood pressure. Patients in whom the tool were used during at least one encounter however or 1.18 times more likely to have had their LDL measured and 1.9 times more likely to have their blood pressure measured that than in those patients in whom the tool was never used. This table also shows that there is no significance difference in the in the proportions of people at target for HbA1c, LDL, or blood pressure at the end of the study.

There was no relationship between the Group (Template vs no template) and the Outcome for Measurement of HbA1c, Proportion of patient with A1c at target, Proportion of patients with systolic BP at target at end of study, or the Proportion of patients with diastolic BP at target at end of study.

However, the tool (Template use during a clinical encounter) was associated with an increased the likelihood that LDL would be measured, that Blood pressure would be measured, and increased the proportion of patients with LDL at target at the end of the study (although this result was borderline significant at p=0.046).
(See Logistic Regression Tables in Appendix 2)

Table 12: Comparison of Patient Outcomes Between Template Used and Template Not Used

Variable		Patients for Whom the Tool was Used at least Once. N=108	Patients for Whom the Tool was Never Used. N=202	P Value	Interpretation
HbA1c Measured according to Guidelines #(%)	**Yes**	108 (100%)	195 (96.5%)	0.101	Patients in whom the template was used during at least one encounter were no more likely to have HbA1c measured than in patients where the template was never used.
	No	0 (0.0%)	7 (3.5%)		
LDL Measure According to Guidelines #(%)	**Yes**	103 (95.4%)	164 (81.2%)	0.001	Patients in whom the template was used during at least one encounter were 1.18 times more likely to have LDL measured than in patients where the template was never used.
	No	5 (4.6%)	38 (18.8%)		
Blood Pressure Measured according to Guidelines #(%)	**Yes**	95 (88.0%)	151 (74.8%)	0.010	Patients in whom the template was used during at least one encounter were 1.9 times more likely to have BP measured than in patients where the template was never used.
	No	13 (12.0%)	51 (25.2%)		
HbA1c at target at end of study #(%)	**Yes**	41 (38.0%)	93 (47.7%)	0.130	No difference between groups in proportion of people with HbA1c at target at end of study
	No	67 (62.0%)	102 (52.3%)		
	Missing	0	7		
LDL at target at end of study #(%)	**Yes**	67 (65.0%)	87 (53.0%)	0.071	No difference between groups in proportion of people with LDL at target at end of study
	No	36 (35.0%)	77 (47.0%)		
	Missing	5	38		
Systolic BP at Target at end of study #(%)	**Yes**	43 (45.3%)	83 (55.0%)	0.177	No difference between groups in proportion of people with systolic BP at target at end of study
	No	52 (54.7%)	68 (45.0%)		
	Missing	13	51		
Systolic BP at Target at end of study #(%)	**Yes**	70 (73.7%)	100 (66.2%)	0.275	No difference between groups in proportion of people with diastolic BP at target at end of study
	No	25 (26.3%)	51 (33.8%)		
	Missing				

CHAPTER 4: Discussion of all sections

4.1 Background

This discussion will cover the three main topics of this thesis: the literature; developing the intervention; and the study. This discussion contains: a background on the thesis; highlights of the literature in relation to the study; highlights of the literature on development of tools compared to the tool studies; implications for practice; recommendations for future research; and conclusions.

The literature suggests the implementation of information enabled diabetes management has demonstrated the potential to improve the process of delivering care, preventing the development of diabetic complications, and generate cost savings. The dynamic nature of the primary care practice environment represents a significant challenge to realizing these theoretical benefits when deploying EMRs in guideline based chronic disease management. Successful interventions require considerable change management process sensitive to the character of each ambulatory practice environment with an emphasis on planned care of the diabetic patient and the use of simple flow charts to graphically represent trends in values and to facilitate decision-making directed at improving clinical markers.

Newfoundland and Labrador is the province with the highest rate of diabetes in Canada with 9.4% of the population affected in 2010 and a cost of care of $254 million dollars annually. The incidence of diabetes in the Central Regional Health Care Authority and the practices under study were even greater at 11% and 14.4% respectively. Using an EMR to manage this chronic disease occurs in the post-implementation phase of an EMR deployment when

the clinicians are comfortable with the basic functionalities such as encounter documentation, prescription creation and renewal, and ordering of lab and diagnostic imagery tests. At this point EMR use has matured to the extent that clinical work flow and process of delivering care can shift to use of templates, premade laboratory requisitions, prepared consultations, flow sheets and patient alerts to manage diabetic care.

The tool under study was developed so that the physicians began each clinical encounter in the usual manner, once they opened a diabetic patient's chart they had opportunity to load a prepared diabetic encounter which automatically imported a care plan complete with diagnosis, prepared consultation letters and populated clinically meaningful values (HbA1c, LDL, BP) into searchable fields. The tool was beta tested for a six month period and then launched with a one hour individual instructional session given by a dedicated HIT educator using a professionally produced instructional manual. Additional sessions were available to each provider on request.

The research question was to determine if the advanced feature of the electronic medical record improved the process of diabetic care in such a way as to improve clinical outcomes. When physicians used the diabetic tool during at least one encounter patients were 1.18 times more likely to have their LDL measures and 1.9 times more likely to have their blood pressure measured. Logistic regression analysis indicated that the intervention increased the proportion of patients with LDL at target at the end of the study.

4.2 Comparison of the Study Findings to the Literature

Of the physicians understudy 42% of them used the tool at least once, obsticles to use may have been the perceived increase in time required to use the tool or the question of the need for a tool to improve the management of diabetics in their individual practices. In 2008 Wyne et al showed technology enabled diabetes management to have significant potential to improve the process of delivery of care to diabetic patients. The use of a diabetic register, which identified the patients requiring focused care, was noted to be particularly important. Similar findings were seen in our research, in diabetic patients for whom the tool was used were 1.18 times more likely to have their LDL measured and 1.9 times more likely to have their blood pressure taken. Increased numbers of LDL tests ordered do not necessarily lead to improved metabolic control (O'Connor 2005) and the use of an EMR in primary care practice is insufficient for ensuring high quality diabetic care (Crosson 2007). However in this study the LDL targets were better met with the tool was used.

The use of chronic diabetes management tools within an EMR is variable. Implementation depends upon a number of factors including a change management process, which requires both sound technical and personal related organizational components (Lorenzi 2009) and a synergy between multiple approaches to encourage adoption (Bowens 2010). Successful use of a specialized EMR tool for the measurement of the diabetic patient requires a combination of tailored office workflow process and adherence to diabetic guidelines and only physicians who changed their workflow to include diabetes specific visits were able to incorporate the EMR tool into their practice (Ciemins 2009). Demonstrating again those efforts to expand EMR use should focus not only on improving technology but also on

developing methods for implementation and integrating technology into practice reality. The variability in the use of the tool in the study reported in this thesis created a naturally occurring experiment and allowed the comparative study to be conducted.

4.3 How does the development of the tool under study compare to the tools cited in the literature.

Electronic medical records, according to Love et al, have the potential to facilitate the design of large cluster randomized trials (CRTs), which are a preferred design to test interventions intended to change physician or patient behavior. In his research, the Diabetes Improvement Group-Intervention Trial (Dig-IT), Love was able to identify and balance pre-assigned characteristics for 12 675 patients cared for by 147 physicians in 24 practices all using the same EMR. This allowed him to determine the effect of experiential interventions of either EMR facilitated disease management or patient empowerment with or without disease management. They showed that rigorous CRT designs allowing for fair comparisons are possible.

This study was not a CRT but rather a retrospective cohort study design to determine if the advanced features of an EMR in primary care clinics could improve the process and outcomes associated with diabetic care. That notwithstanding, the same approach was used to compare patients between practices and as seen in Table 3.1 shows the two groups were similar on some variables. Variables that were not similar between groups were controlled in the analysis using logistic regression.

The translate trial was a multi component organizational intervention conducted in a primary care setting (Peterson 2008). The intervention targeted a number of the components of the chronic disease care model including implementation of an electronic diabetes registry; visit reminders and patient and physician specific alerts. The electronic diabetes registry was either incorporated into an existing computer system or placed on a new computer system and a site coordinator trained in its use. The coordinator facilitated pre visit planning and provided patient and physician specific reminders for each diabetic patient visit. The site coordinator notified patients of scheduled visits and contacted high risk patients with an elevated HbA1c or SBP as well as providing monthly summaries of operational activity and tracked clinical measures. This produced significant increases in the percentage of type two diabetic patients achieving recommended outcomes.

The tool under study in this study involved the production of a diabetic registry that was incorporated into an existing EMR system, which included visit reminders and physician specific alerts. In the absence of a site coordinator, it was the responsibility of each physician to identify high-risk patients and track clinical measures.

Research into typical use of EMR in primary care practices comparing 16 EMR using practices to 26 non-EMR using practices in a group-randomized quality improvement trial showed that non-EMR practices were more likely to meet the targeted outcomes for HBA1c, LDL, and blood pressure (Crosson 2012). The authors of this study suggested that this result might have stemmed from the EMR practices not investing enough in changes to work process and conceptualization of how this technology can be used in improving chronic

illness management. Given the population management functions in commercially available EMR are poor and an optional component of meaningful use criteria[67] this finding is not surprising. As noted above the solution in part would be to assign a member of the health care team to maintain disease registries.

The change management process with the launch of the EMR in the clinics under study was dedicated to basic electronic record keeping, billing processes and clinical workflow only in so far as it pertains to scheduling of appointments. The study tool represented the first attempt at advanced disease management with a focus on process and outcomes.

A five year longitudinal study of 122 adult type II diabetic patients involving EMR and non-EMR clinics showed EMR use lead to an increased number of HbA1c and LDL tests being ordered but no improvement in metabolic outcomes (O'Connor 2005). It was thought EMR use would assist in overcoming clinical inertia, defined as a failure to intensify treatment in patients who have not achieved evidence based clinical goals, which has been cited as being as high as 50%. The data suggested that in spite of the increased technical sophistication of EMRs the link between processes of care and outcomes of care was tenuous; the level of HbA1c and not the frequency of ordering the tests is what predict the risk of complications and increased health costs.

The practice tools studied in this thesis research demonstrated similar findings with a difference in the frequency of LDL and BP measurements but no appreciable improvement

in the proportion of people at target for HbA1c or blood pressure. However, it did find an increase in one clinical outcome, better LDL control.

A pre/post-intervention cohort analysis of 495 type two diabetic patients followed for six years showed an increased adherence to ADA guidelines (Ciemins 2009). This study consisted of two intervention phases; a "Low dose" period of targeted education to patients and providers followed by a "high dose" diabetes management implementation phase. The "high dose" intervention period was characterized by implementing an integrated EHR that changed the clinic's approach to managing complex chronic conditions. A diabetic registry was constructed; point of care provider alerts and a diabetic management module was designed, electronic forms for documentation created and patient and provider report cards generated. At the study's end patients were 3.5-6 times more likely to have been screened for diabetic complications, 11 times more likely to have had tests ordered, and 2-3 times more likely to have HbA1c, LDL, and BP controlled.

The absence of "high dose" diabetic management implementation phase with physician and patient report cards meant that in practices considered in this author's study that only three of the seven physicians used the tool for their diabetic clinical encounters. These were part of the four-physician group practicing in the clinic where this author was located.

4.4 Strengths and limitations

A randomized clinical trial would have been preferred over a retrospective cohort study but was not possible in this real world setting. The physician's choice on whether or not to use

the tool limits this to an observational study preventing controlling for all confounders; such as method of physician remuneration and patients geographical factors. The design did however allow for controlling for patient age, sex, and number of visits.

4.5 Implications for practice

The Canadian EMR adoption model advances that improvement in patient outcomes, measured in terms of reduced morbidity and mortality, follow naturally as a result of improvement in care processes. The advanced EMR features used during the diabetic study were designed to improve care processes using a visit template, prepared laboratory requisitions, flow sheets (populated when laboratory values were entered into a defined field), and patient alerts. Each one of these functionalities individually represented a feature of the Nightingale EMR that each of the participating physicians was familiar with. However this is the first time that all of those tools had been combined in the delivery of Clinical Practice Guideline informed care. As such the intervention may have been daunting to some of the clinicians and physician attitudes including skepticism about implementing GPGs into their practice may also have been a factor on the EMR advanced features use.

The change management during the post implementation phase of the EMR in Central Newfoundland was focused on the support of basic EMR usage and as such it rates at EMR adoption level one on the six point Canadian EMR Adoption and Maturity Model. The advanced EMR functionalities under study-represented maturity levels two and three attempting to structure workflow for diabetic patients, standardize data, and focusing on

meaningful clinical outcomes. As such it may have exceeded the sophistication of EMR use by some of the providers.

The successful use of advanced EMR features, in guideline based chronic disease management, requires understandable user-friendly technology, expert training, and a solid change management process. The change management processes must support all aspects of change both technical and personal. The intervention did not have a method beyond education to support the physicians in making the changes required for the use of the advanced diabetic management tool under study. The clinic with a 75% use of the intervention did have an informal champion in that the author was imbedded in that clinic. The individual character of each ambulatory practice may have also impacted on the tools use, as the physicians with the higher percentage of diabetic patients in their practices were more likely to use the tool.

It may be reasonable to conceptualize the treatment of diabetic patients in EMR clinics in terms of process of care delivery and clinically significant outcome measures, and that this treatment be delivered in a serial and progressive manner. With the identification of a diabetic patient the clinician uses the basic recordkeeping functions of the EMR to document clinical encounters, order required labs and medications and identify the patient to a diabetic registry. The diabetic registry is constructed in such a way as to book follow up appointments for diabetic specific visits, risk stratify patients based upon clinical outcome measures. Clinical encounter templates then shift the process of care to clinical processes, such as, starting and titrating metformin to as close to UKPDS 38 levels as the patient will

tolerate and then shift pharmacological management to LDL and blood pressure control. The final stage in EMR use would be a shift to advanced disease management where patients not achieving clinical outcomes are identified for more intensive interventions and those at targets have their care shifted to the management of the complications of diabetes.

4.6 Recommendations for future research

In the absence of significant incentives and disincentives to promote the meaningful use of electronic medical records in smaller jurisdictions such as Newfoundland and Labrador, research into the characteristics of physicians and practices that would lend themselves to the use of advanced EMR functionality would be of merit. Audit tools to help these individual clinicians identify areas of their practices that would benefit from advanced EMR functionality would personalize such interventions. Research also conducted to identify the optimal number of advanced features that can be used by a clinician during any one clinical encounter would also be of particular value.

4.7 Conclusions

Electronic medical records are physician centric computer-based tools containing patient demographics, medical and drug history, as well as diagnostic and laboratory information presented in a manner that may or may not promote chronic disease management. They have been described as being transformative in nature, with the potential to fundamentally change the work, productivity, and processes of delivering care in community-based practices. Chronic disease in general, and diabetes in particular present an ideal opportunity for health information technology to demonstrate its ability to improve the provision of chronic disease management in primary care medicine. Successful EMR

implementation in guideline based chronic disease management is multifactorial and requires consideration of the technology itself, training of physicians, leadership in clinical excellence, and the individual character of each ambulatory practice environment. A solid change management process that an EMR in the primary care setting can achieve the maturity necessary to significantly increase the percentage of type II diabetic patients achieving the recommended clinical outcomes only through the introduction of a multicomponent intervention.

Maturity emerges in EMR use is an emergent property from the three separate domains of functionality, breadth, and outcomes. A survey of the EMR usage by the seven physicians being studied indicated that they had experience with the functionalities used in the design of the advanced diabetic patient management tool, subsequently each one of these functionalities was incorporated into the intervention in this study designed to improve the process of delivering diabetic care. The breath of the study included seven physicians caring for three hundred and ten patients who met the study inclusion criteria, with three of those clinicians using the advanced diabetic management tool to care for a total 108 patients. Those patients experienced an improvement in the process of delivering diabetic care being 1.18 times more likely to have had their LDL measured and 1.9 times more likely to have their blood pressure measured during the clinical encounters. In terms of improvement in outcome measures, using logistic regression, there was increase in the proportion of patients with LDL at target at the end of the study.

The meaningful use of EMRs in primary care, is possible through a process of maturity by design; an individualized approach looking at the needs of a given physician(s) and their practice(s) will be most likely to aid EMRs in achieving their potential. The technology needs to support care by automation of clinical processes and work flow behind the computer screen in such a way as to not disrupt or significantly change the patient physician interaction and focus both of these individuals on managing meaningful clinical outcomes personalized to each patient.

Appendices

Appendix 1: <u>Diabetes Study How-To</u>

Current patients who have had a Diabetes Miletus (ICD 0250) diagnosis will have had the Flowchart added to their CPP. All that needs to happen now is loading the Templates and Profiles when the patient is in for the follow-up appointments.

To add the Diabetes Study and flowchart for newly diagnosed patients and send them for their first diabetic panel:
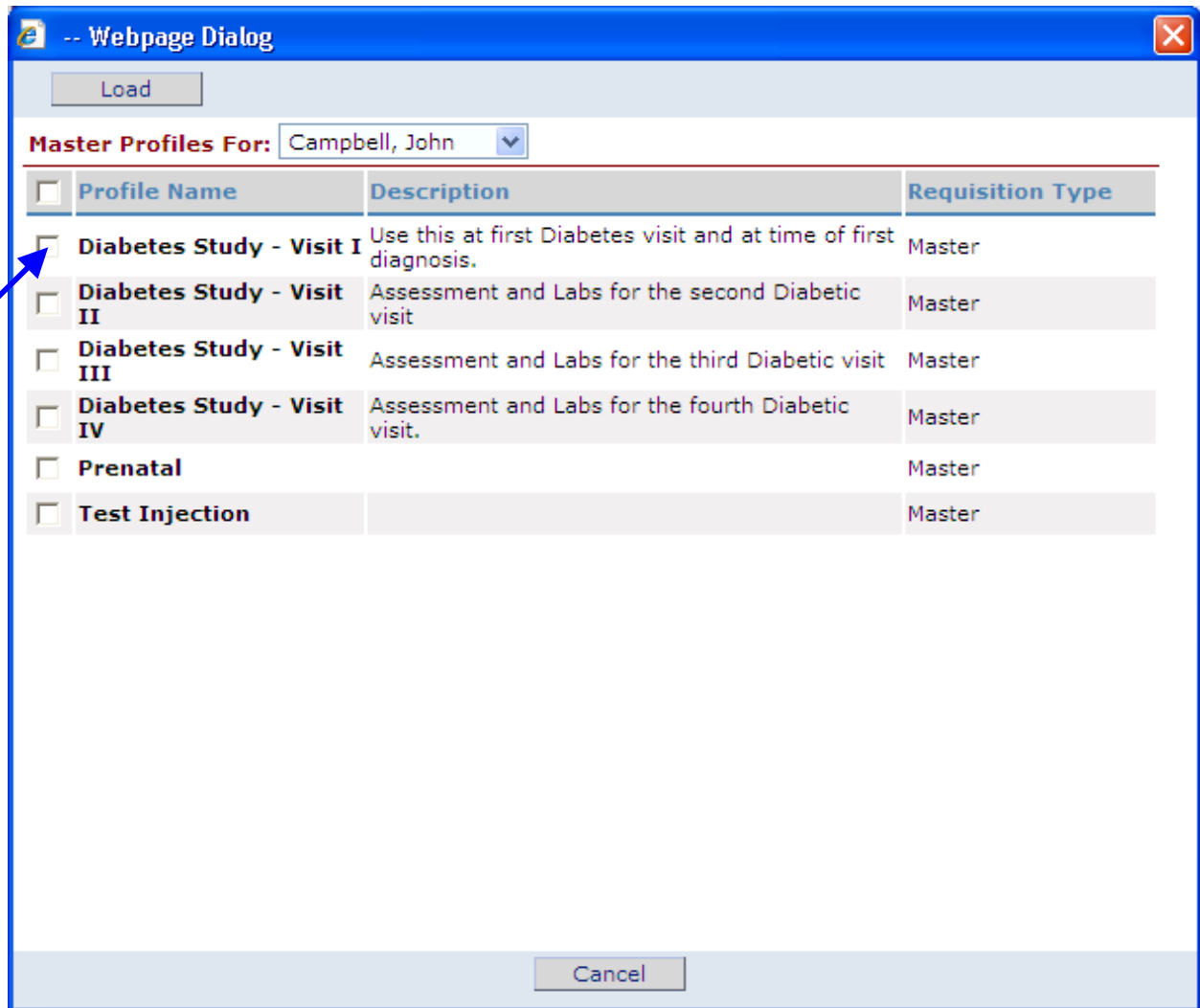
1. Start the Encounter as usual.
2. Click on the "Profile" button at the top left of the Encounter.

3. In the Webpage Dialog window that opens, change the Master Profiles For: to Dr. John Campbell.
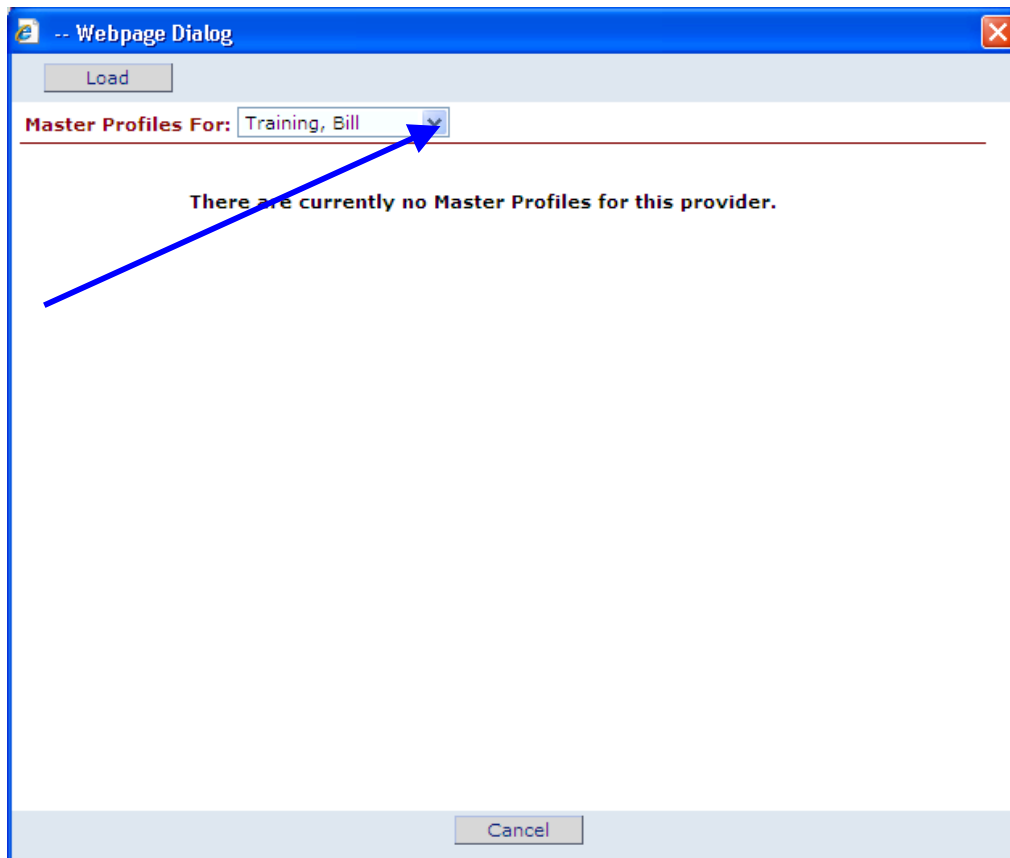
4. In the profiles list, click the box at the right of the Diabetes Study I – Visit I (or whichever visit this is) profile to put a checkmark in it and then click on the LOAD button at the top left of the page. This will load the profile and automatically input the Diagnosis, Consultations, Labs and Plan Notes into the Encounter.

5. Next, click on the LOAD TEMPLATE button at the top left of the page.

6. In the Webpage Dialog window that opens: (a.) change the View: drop down from Provider Templates to Enterprise Templates (b.) click on the checkbox next to *Diabetes Study to put a check mark in it (c.) then click the LOAD button.
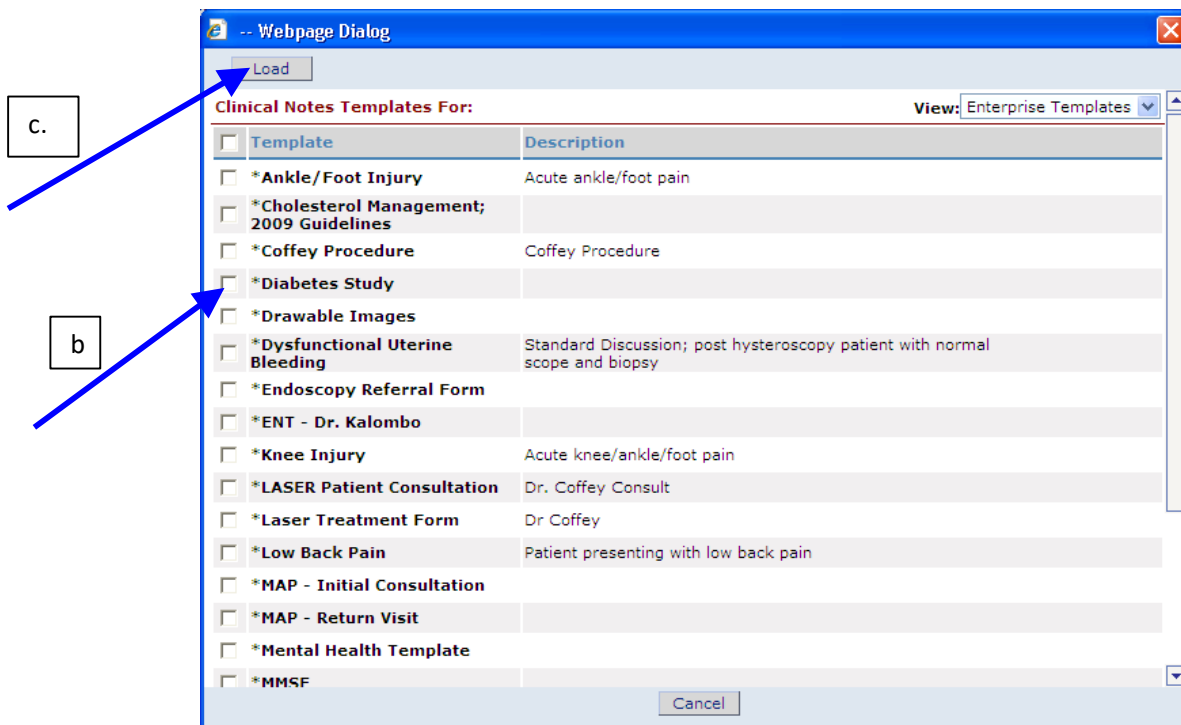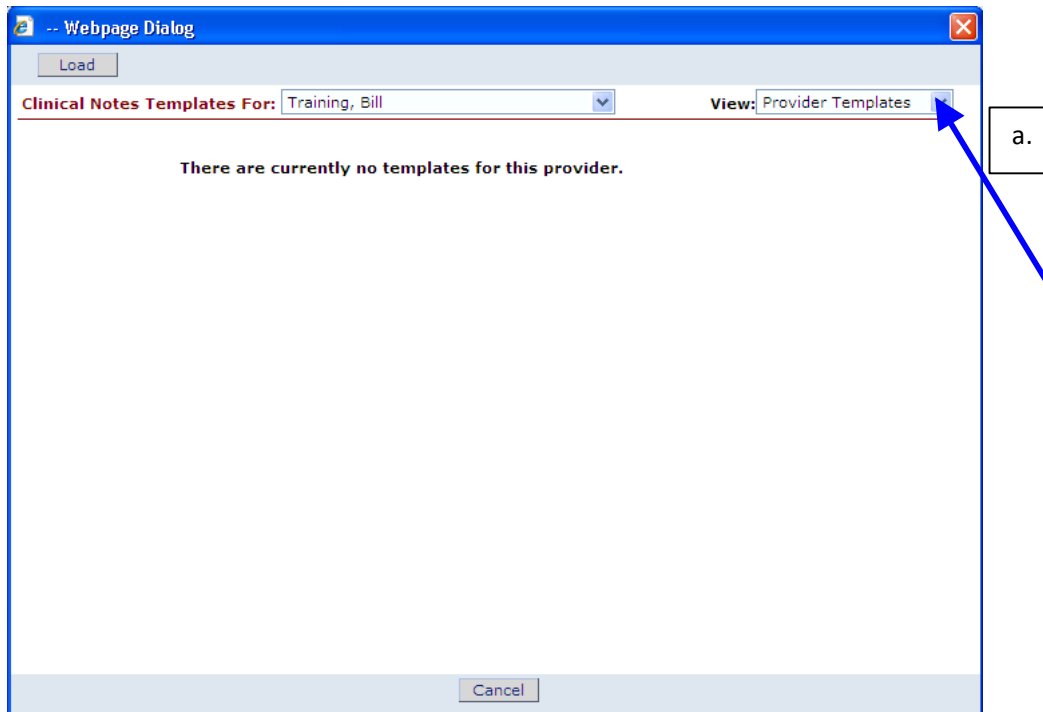
(d.) The template will load and allow entry of data.

1. Fill in all the applicable sections, scroll down or tab into the check and text boxes. When finished, click on the "SAVE" button to save the template into the Encounter. Whatever is filled in will be placed into the Encounter.

2. There are three Consults associated with the first Diabetic session. One for Fundoscopic exam, one for Diabetes Education and one for Diabetes Nutritional Education. You must open each one and assign the Consultant and adjust the preset text to reflect your current patient.
3. There is a Laboratory Requisition associated with this session, and all that is required is asign and print.

4. The Plan Notes are filled in generically, so you need to adjust the text to reflect the current status of your patient.

5. Once everything has been properly filled in, printed, signed and given to the patient, close the encounter in your preferred way.

6.   The data will be collected by the Flowsheet created for this template. In order to activate the flowchart open the patient's CPP and click on the Flowsheet link:

7. With the Flowsheet section heading highlighted in blue click on the Add button that will be in the menu at the top left:

8. a.) Choose the * Diabetes Study by clicking the check box and then the b.) Add button at the top left:

9. The Flowsheet will open a window and collect the data that it is set to collect. Once it has completed collection, you may review the data by a.) sliding the slide bar down. When finished, click on the b.) Save button at the bottom of the window:

10. Once saved, the options at the bottom change to Print, Save or Close. Choose whichever, but when done, choose the Close which will take you back to the CPP and will show the Flowsheet active in the patient's CPP.

11. All that is required now is to book the follow-up appointments. When the patient next comes in, load the next Template and Profile, and fill in the data. The Flowsheet will automatically update the data it is supposed to collect.

The End

Appendix 2: <u>Logistic Regression Tables</u>

a. <u>Dependent Variable: Whether A1c Was Measured according to Guidelines</u>

Variables in the Equation

	Beta	S.E.	Wald	df	Sig.	OR	95% C.I.for OR	
							Lower	Upper
Template Used*	17.944	3810.495	.000	1	.996	62096798.597	.000	.
Age	-.026	.036	.511	1	.475	.974	.907	1.046
Sex	-.890	.852	1.090	1	.296	.411	.077	2.182
Number of Visits	-.236	.813	.084	1	.772	.790	.160	3.887
Constant	5.641	2.616	4.649	1	.031	281.715		

* There is a nul value in the table making measurement of Odd Ratio (OR) erroneous.

b. <u>Dependent Variable: Whether LDL was Measured According to Guidelines</u>

Variables in the Equation

	Beta	S.E.	Wald	df	Sig.	OR	95% C.I.for OR	
							Lower	Upper
Template Used	1.555	.501	9.650	1	.002	4.736	1.775	12.636
Age	.005	.015	.094	1	.760	1.005	.976	1.034
Sex	.726	.349	4.321	1	.038	2.066	1.042	4.095
Number of Visits	-.534	.352	2.299	1	.129	.586	.294	1.169
Constant	1.053	1.016	1.075	1	.300	2.867		

c. <u>Dependent Variable: Whether BP was Measured According to Guidelines</u>

Variables in the Equation

	B	S.E.	Wald	df	Sig.	OR	95% C.I.for OR	
							Lower	Upper
Template Used	.792	.347	5.201	1	.023	2.207	1.118	4.357
Age	.025	.013	3.907	1	.048	1.025	1.000	1.051
Sex	-.629	.298	4.451	1	.035	.533	.297	.956
Number of Visits	.201	.313	.412	1	.521	1.223	.662	2.257
Constant	-.192	.856	.050	1	.823	.825		

d. <u>Dependent Variable: Whether HbA1c was at target at End of Study</u>

Variables in the Equation

	B	S.E.	Wald	df	Sig.	OR	95% C.I.for OR Lower	Upper
Step 1[a] Template Used	-.433	.350	1.532	1	.216	.649	.327	1.287
Age	-.026	.017	2.226	1	.136	.975	.942	1.008
Sex	-.303	.343	.783	1	.376	.738	.377	1.446
Number of Visits	-.821	.376	4.770	1	.029	.440	.211	.919
Baseline A1c	-2.663	.324	67.583	1	.000	.070	.037	.132
Constant	21.047	2.634	63.862	1	.000	1382631855.181		

e. <u>Dependent Variable: Whether LDL was at target at End of Study</u>

Variables in the Equation

	B	S.E.	Wald	Df	Sig.	Exp(B)	95% C.I.for EXP(B) Lower	Upper
Template Used	.772	.387	3.981	1	.046	2.165	1.014	4.623
Age	-.017	.017	.971	1	.324	.983	.951	1.017
Sex	.555	.375	2.188	1	.139	1.742	.835	3.633
Number of Visits	.434	.388	1.253	1	.263	1.544	.722	3.301
Baseline LDL	3.526	.382	85.229	1	.000	33.986	16.077	71.846
Constant	-1.240	1.141	1.180	1	.277	.289		

f. <u>Dependent Variable: Whether Systolic BP was at Target at End of Study</u>

Variables in the Equation

	B	S.E.	Wald	Df	Sig.	OR	95% C.I.for OR Lower	Upper
Template Used	-.279	.291	.918	1	.338	.757	.428	1.338
Age	-.032	.014	5.016	1	.025	.969	.943	.996
Sex	.079	.284	.077	1	.782	1.082	.620	1.888
Number of Visits	-.365	.303	1.453	1	.228	.694	.384	1.257
Baseline systolic BP	-.032	.011	8.699	1	.003	.969	.949	.989
Constant	6.367	1.610	15.646	1	.000	582.279		

g. <u>Dependent Variable: Whether Diastolic BP was at Target at End of Study</u>

Variables in the Equation

	B	S.E.	Wald	df	Sig.	OR	95% C.I.for OR Lower	Upper
Template Used	.309	.326	.900	1	.343	1.362	.719	2.580
Age	.011	.015	.553	1	.457	1.011	.982	1.040
Sex	.131	.309	.180	1	.671	1.140	.622	2.088
Number of Visits	-.209	.323	.419	1	.517	.811	.431	1.528
Baseline Diastolic BP	-.072	.021	12.157	1	.000	.931	.894	.969
Constant	5.200	1.910	7.412	1	.006	181.334		

Appendix 3: Characteristics of Physicians

a. Physicians using tool

Sex	Method of Remuneration	Graduation Date
Male	**Fee for service**	**2004**
Female	**Salary**	**2004**
Female	**Fee for service**	**2001**

b. Physicians not using tool

Sex	Method of remuneration	Graduation Date
Male	**Fee for service**	**2003**
Male	**Fee for service**	**2010**
Female	**Salary**	**2010**
Female	**Fee for service**	**2003**

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Dr. John A. Campbell CCFP-EM

Associate Clinical Professor Family Medicine
Memorial University

EDUCATION

July 2004-June 2005	**Emergency Medicine Residency,** Western University, London ON
July 2002-June 2004	**Family Practice Residency,** Memorial University, St. John's NF
September 1998-May 2002	**Medical Doctorate,** Memorial University, St. John's, NF
September 1995-May 1998	**Bachelor of Science (Pre-med),** University of Victoria, Victoria, BC

TEACHING EXPERIENCE

Associate Clinical Professor FM (2011- Present) with teaching responsibilities including community based family medicine, academic family medicine, emergency medicine for family practice residents, and enhanced skills training for residents in the Program for Enhanced Rural and Remote Training.

Assistant Clinical Professor FM (2007-2011) with teaching responsibilities including community based family medicine, academic family medicine, emergency medicine for family practice residents, and the Advanced Pediatric Life Support Course (APLS) for all family practice residents.

Clinical Preceptor for CSAT program (2006-2013) with clinical teaching in the disciplines of family and emergency medicine.

RESEARCH EXPERIENCE

June 2010-2013	Sub-investigator on *Tiosphere a randomized phase IIIb clinical trial relating to COPD management*

September 2008-2009	Principle author on an *Obsevership Project for International Medical Graduates* funded by Health Canada
June 2007-November 2009	Lead Investigator *Survey of Facilities Providing Emergency Care in Central Newfoundland* conducted Central Health Care Authority
March 2003-December 2003	Co-investigator *Pain Management in Renal Colic*, conducted in two emergency departments of the Health Care Corporation St. John's
August 2000	*Summer studentship* assisting in research of Dr. Michael Murray, Faculty of Medicine, Department of Community Medicine, Memorial University
July 2000	*Elective research*, Dr. Jack Newman, Child and Adolescent Health Unit, Toronto, Ont.
July & August 1999	*Summer studentship* assisting in research of Dr. Michael Murray, Faculty of Medicine, Department of Community Medicine, Memorial University

PUBLICATIONS

Campbell, J.A. *When Things Go Wrong*. Canadian Family Physician. May 2005.

Campbell, J.A. *A Fresh Start*. Canadian Family Physician. August 2003.

Campbell, J.A. *Thoughts on Residency*. Canadian Family Physician. September 2003.

Campbell, J.A. *The College and You*. Canadian Family Physician. April 2004

PRESENTATIONS

Campbell J.A., *Privatization of Palliative Care*, Prifor Dangerous Idea Soapbox, St. John's July 2015.

Campbell J.A., *Evaluating Cognitive Error in Learners*, Preceptor Meetings, Corner Brook 2013; St. John's 2012.

Campbell J.A., *An Emergency Approach to CVA/TIA Assessment*. Presented Fall 2012 Wednesday @ Noon –Ask the Consultant Series October 2012.

Campbell J.A., *Executive Summary of Emergency Medicine Services in Central Newfoundland.* Presented to Senior Executive Central Health Care Authority February 2009.

Campbell J.A. *Conceptualization of the Provision of Emergency Services in Central Health.* Presented to Senior Executive Central Health Care Authority October 2007.

Campbell J.A., *Preparing Your Office for a Medical Emergency* presented Family Practice Symposium July 2008 Terra Nova NL.

Campbell J. A., and Halliday B. *The Impact of Fifty Years of Family Medicine: Looking Forward-Looking Back* The Hannah Lecture at FMF November 2004 Toronto ON.

Campbell J.A*., Induction of Labor Practices in Grand Falls Windsor and the SOGC* Guidelines, Presented as Grand Rounds, October 2002 Grand Falls-Windsor, NF.

Campbell J.A., and Sparrow S.M. *The Use of Methadone in Palliative Care Pain Management*, Presentation to the Palliative Care Physicians of Victoria, January 2002 Victoria, BC.

POSTERS

Campbell J.A., T. Micks, E. Bautista, R. Brooks, H. Bruce, G. Higgins, K. Jim, T. Kabisios, J. Mercer, S. Parsons, S. Ralph, R. Ryan., *Interdisciplinary Collaboration for Improved Maternal-Fetal Outcomes in Central Newfoundland.* Poster Presentation at The Primary Healthcare Partnership Forum – St. John's, NL June 2015.

Campbell J.A., T. Micks, M. Sherman, L. Rourke., *Resuscitating the Family Medicine Curriculum: A Novel Approach to Postgraduate Advanced Life Support skill Acquisition and Maintenance.* Poster presentation SRPC April 2015 Vancouver, BC and The Primary Healthcare Partnership Forum – St. John's, NL June 2015.

Campbell J.A*,* Patti McCarthy, Bob Miller, Cheri Bethune, Ean Parsons, Marshall Godwin, Roger Butler, Leslie Rourke, Lyn Power, Sandy MacDonald, Madeline Cole, Lisa Grant, Reanne Meuse, Shannon Fisher., *Docs on the Rocks: A Recipe for a Better Cocktail*. Poster presentation SRPC 2013 Vancouver, BC

Campbell J.A., Lynette Powell, Patti McCarthy, Kris Luscombe, Richard Lush, Colin Newman, Mark O'Driscoll, Steve Parsons, Leslie Rourke, Bob Miller, *Interprofessional Teaching* in a Rural Residency Teaching Site. Poster presentation SRPC 2013 Vancouver, BC

Campbell J.A. *Killick Health Services and Family Medicine Education*. Poster presentation FMF October 2010 Vancouver, BC

Campbell J.A., Bannister E., Fleet L., *Providing International Medical Graduates with Advanced Training and Support for Licensure*. Poster presentation IEHP Atlantic Symposium, February 2010, Halifax, NS.

Campbell J.A., Bannister E., Fleet L., *Providing International Medical Graduates with Advanced Training and Support for Licensure*. AMEE August/September 2009 Malaga, Spain.

Campbell J.A., and Campbell S.M. *A Comparison of IV Meperidine, Meperidine and Keterolac, and Fentanyl and Keterolac in ED Treatment of Renal Colic Pain*, Resident's Research Forum, March 2004 St. John's NL.

AWARDS AND CERTIFICATES

Educational and Teaching Awards
Gus Rowe Award, Memorial University (2015)
Research Directors Award (2004)
The Mary Honeygold Scholarship (2002)
Medical Doctorate Memorial University Dean's list (2002)
BSC with Distinction, University of Victoria (1998)

Professional Awards
CFPC Early Career Development Award (2008)
CFPC Family Medicine Resident Leadership Award (2003)

Certificates
Instructor:
Neonatal Resuscitation Instructor (2014)
Advanced Trauma Life Support Instructor (2012)
Advanced Pediatric and Life Support Instructor and Course director (2009)
Advanced Cardiac Life Support Instructors Course (2006)
Provider
Advanced Pediatric and Life Support (2009, 2005)
Advanced Life Support Obstetrics (2009, 2004)
Advanced Cardiac Life Support (2006, 2002)
Pediatric Life Support Course (2005)
Toxicology Road Show (2005)
AIM (2005)
NRP (2004)
Advanced Trauma Life Support (2004)

First Aid and Basic CPR Certificates (2000)

Awards for Military Service
United Nation's Peace Keeping Medal Former Yugoslavia (1995)
Special Service Force Ironman Competition (1991 & 1993)
Persian Gulf War Service Medal (1991)
Liberation of Kuwait Medal (1991)
United Nation's Peace Keeping Medal Cyprus (1989)

POSITIONS HELD AND PROFESSIONAL AFFILIATIONS

Current:
Co-Chair Prehospital Care CNRHC (2015-Present)
Regional Medical Advisor Paramedicine CNRHC (2015-Present)
Newfoundland and Labrador College of Physicians and Surgeons Board Member (2010-Present)
Member of Laboratory Interface Working Group EHR Project NLCHI (2010-Present)
Member of Pharmacy Governance Advisory Board NLCHI (2010-Present)
Member CPHSC (2010-Present)
Member primary care research network (Sept 2009-Present)
Canadian Association of Emergency Physicians (2004-Present)
Canadian Medical Association (1998-Present)
Newfoundland and Labrador Medical Association (1998-Present)
Past:
President Medical Staff CRNHC (2009- 2010)
Peer to Peer Network NLCHI (2008-2009)
Secretary Medical Staff CRNHC (2008 – 2009)
Co-Chair Quality Initiatives Emergency Medicine Central West Health Care Board (2006-2013)
Membership Advisory Committee National Chapter CFPC (2007- 2009)
Member at Large Provincial Chapter CFPC (2006-2009)
Palliative Care Committee (2005-2010)
Chair of the Section of Residents for CFPC (2003-2004)
Administrative Resident Family Medicine Program (2003-2004)
Editorial Advisory Board for *Canadian Family Physician* (2002-2004)

LEISURE ACTIVITIES

The preparation and cooking of fine foods
Applied automotive sciences in the restoration of a 1980 Camero

VOLUNTEER EXPERIENCE

Responsible sexuality project Organized project, revised manual and conducted training. (1999 and 2000)

Palliative Care volunteers Victoria Hospice, Victoria, BC (December 1997- May 1998)