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Factors Associated with Specialist Referral for Patients with Type 2 Diabetes in Southwestern and Central Ontario

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Factors Associated with Specialist Referral for Patients with Type 2 Diabetes in Southwestern and Central Ontario

(Determinants of specialist referral for diabetes care)

(Monograph)

by

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Abstract and Keywords

Objective: Determine the referral rate and the visit and patient factors associated with specialist referral for patients with type 2 diabetes.

Methods: Sample consisted of 9,443 patient-physician visits from eight family practice groups in southwestern and central Ontario. GEE was used for the regression analysis.

Results: The referral rate was 3.7 referrals per 100 patient visits. The odds of referral decreased if a visit occurred with a female patient and if an ACR measurement was not available at the visit. A one year increase in the number of years with the family physician resulted in a lower odds of referral. The odds of referral increased if the patient had a specialist appointment in the previous two years, if lifestyle counseling occurred and if a neuropathy examination was performed.

Conclusions: Further research should assess the influence of visit level factors on decision making. Guidelines for specialist referral should also be considered.

Keywords: Type 2 Diabetes, Specialist Care, Primary Care Physician, Determinants of Referral, Referral Rate.

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Abbreviations

A1C	Glycated Hemoglobin
ACR	Albumin/Creatinine ratio
BMI	Body Mass Index
CDA	Canadian Diabetes Association
CI	Confidence Interval
CKD	Chronic Kidney Disease
CME	Continuing Medical Education
CPG	Clinical Practice Guidelines
DEC	Diabetes Education Centre
Diabetes Mellitus	Diabetes
FFS	Fee-For-Service
GEE	Generalized Estimating Equations
GLM	Generalized Linear Model
GOF	Goodness of Fit
HDL	High-Density Lipoprotein
ICES	Institute for Clinical Evaluative Sciences
LDL	Low-density Lipoprotein
LHIN	Local Health Integration Network
MeSH	Medical Subject Heading
PCP	Primary Care Physician
POC	Point of Care
PVD	Peripheral Vascular Disease
ROC	Receiver Operating Characteristic Curve
SD	Standard Deviation
UK	United Kingdom
US	United States
WHO	World Health Organization

Chapter 1
Introduction

Diabetes Mellitus

Diabetes Mellitus (diabetes) is a medical condition characterized by problems with the production and/or use of insulin. Insulin is a hormone that is directly involved in the uptake of glucose into the cells of the body. Glucose is subsequently used by the cells to produce energy. Diabetes is a chronic disease, and can be further classified as one of three types depending on the type of insulin problem. Type 1 diabetes is typically diagnosed in children and results from the inability of the pancreas to properly produce insulin. Type 2 diabetes can also involve an improperly functioning pancreas but more typically involves the inability of body cells to respond to insulin. Type 2 diabetes is often classified as an "adult-onset" disease, but has recently become a common diagnosis in younger individuals. Another type of diabetes is gestational diabetes, which is a temporary condition that can occur in women during pregnancy.

These three types of diabetes affect distinct groups of individuals with differing causes and management techniques. The cause of type 1 diabetes is unknown and treatment involves an external supply of insulin to regulate blood sugar levels. The exact mechanism by which type 2 diabetes occurs is unknown, but it is known to be related to poor diet and lifestyle. It is a progressive disease by which an individual can be in a state of "pre-diabetes" for many years before a diagnosis is made. Treatment can involve a combination of medication and lifestyle intervention. If left untreated, both type 1 and type 2 diabetes can result in multiple complications and co morbidities including retinopathy, hypertension, neuropathy, nephropathy and cardiovascular disease.

Burden of Diabetes

Approximately 246 million people worldwide are affected by diabetes (1). This number is expected to reach 380 million by 2025 (1). In Canada, the number of cases of diabetes

was estimated at over two million for 2007 (1). This number is expected to rise to three million by 2010 (1). From 1995 to 2005 the prevalence of diabetes increased steadily by an average rate of 6.2% per year (2). A child in Canada in the year 2000 was believed to have a one in three chance of developing diabetes in their lifetime (1).

Approximately 90% of the present and incident cases of diabetes are type 2 diabetes. This is important to note because the prevalence and incidence of type 1 and type 2 diabetes are often grouped together in the literature even though individuals with type 2 diabetes are a unique subset of population with diabetes. These patients typically have a greater set of coexisting medical conditions (3) and face a more difficult time managing their disease. Type 2 diabetes, in particular, is on the rise because of the increasing prevalence of obesity, more sedentary lifestyles, an aging population, and the high rates of immigration of high-risk groups such as Hispanics, Asians, South Asians and Africans (1). It is estimated that 10% of the adult population in Ontario will be diagnosed with diabetes by 2010 (2).

The cost of diabetes to Canada's healthcare system was estimated at $4.6 billion in 2000 (4). This value is expected to increase to $8.1 billion by 2016 (4). Compared to the general population, an individual with diabetes costs $2930 more to treat during the year of diagnosis and $1240 more in subsequent years (4). The higher costs were found to be associated with a greater number of co morbidities (4). Patients with type 2 diabetes tend to suffer from a greater number of conditions and co morbidities and are therefore placing a greater burden on our health care system. Studies in Canada, the United States (US) and the United Kingdom (UK) offer mixed results on which complications are the most costly but it is agreed that diabetes related complications if not managed early in the course of disease may lead to even more costly conditions (5). Approximately 3.5% of all health care spending in Canada is used to deal with the direct costs of diabetes care (6). This number is expected to continue to rise (6).

Coordination of Diabetes Care

Many organizations, such as the World Health Organization (WHO), the Canadian Diabetes Association (CDA), and the Institute for Clinical Evaluative Sciences (ICES) have highlighted key areas of concern and opportunity for a successful chronic care model for diabetes. The WHO for example, provided a model for chronic care that stressed the importance of health system organization of healthcare and decision support for improving care (7). ICES recommended that shared care models, interdisciplinary services and methods to keep better track of the coordination of care be developed in the future (8). Furthermore, Beaulieu et al (9) stressed that family medicine is "struggling for a clear identity" and stated that the flow of patients from primary to secondary care may be suboptimal. The agenda for diabetes care in Canada is pushing towards an integrated system with interdisciplinary collaboration and support.

Diabetes management is the responsibility of the patient and their family doctor alongside a family health team and/or specialist care (10). The interaction between these caregivers allows for effective management and continuity of care. In Ontario in 2000, 75% of the population with diabetes was under the care of only their family physician (10).

The CDA has forecasted that by 2020, the number of general practitioner visits will be more than 14 million; a significant increase from the 5 million in 2000 (6). In the same time period, the number of visits to specialists is expected to increase from 3.2 million to 9.1 million (6). These two factors will significantly effect the growth of diabetes care costs from 2010 to 2020 and are expected to "severely tax the healthcare system over the next decade" (6). Diabetes is especially taxing on the health care system because it is a chronic condition that requires more intensive use of resources compared to other conditions. In combination with an increased demand for resources, family physician and specialist shortages (11) are placing extreme pressures on existing health care resources.

Diabetes Care Research Priorities in Canada

In recognition of the incredible burden of diabetes on our healthcare system, the CDA invested more than $6.8 million in diabetes research in 2009. This money was aimed at supporting 47 new projects and 77 ongoing projects that addressed the prevention and management of diabetes and its complications (12).

In 2009, the CDA developed a Diabetes Cost Model to assess the impact of a hypothetical campaign to reduce the number of individuals with diabetes, the number of associated complications and the number of generalist and specialist visits. It is believed that directing resources at patient education and healthcare resource management will reduce healthcare utilization. That is, a more educated patient and more effective management techniques will lead to fewer patient medical problems and therefore fewer visits to the doctor (6).

Provincially, Ontario launched a $741 million diabetes strategy (13) that focused on improving the prevention, management and treatment of diabetes, including a component on increasing access to team based care. The Ontario Health Quality Council also addressed the importance of adapting primary care to support chronic disease management demands (14).

One important component of diabetes care that has not been specifically addressed in Ontario is the transition of patients between primary and secondary care. Clinical Practice Guidelines (CPG's) for the management of diabetes in Ontario have been developed to guide effective diabetes management. They review the important tests useful for assessing a patient with diabetes for conditions such as nephropathy or hypertension. However, there are only limited notes addressing when a referral to specialist care is appropriate. The guidelines include a discussion of the timing of self-management referrals and state that "case management or care coordination should be considered for difficult to manage cases."(7)

Research Objectives

Referrals for patients with diabetes are often discretionary in nature because these individuals have a chronic disease and are often suffering from multiple complications. Team based collaboration between practitioners has become increasingly common. It is generally known that a family physician will refer their patient to a Diabetes Education Centre (DEC) if newly diagnosed, and that they are to perform routine tests and laboratory examinations for their patient. Also, they know that they should refer a patient to a cardiologist if there are heart problems or an ophthalmologist if there are eye problems. However, there are no specific guidelines which advise the physician when a referral should be made and to whom.

Assessing the factors associated with a referral; especially in populations with type 2 diabetes is quite new. The literature reveals a large amount of discrepancy as to what variables to assess and their direction of influence. Therefore, our study was relatively exploratory in nature. We aimed to contribute to the understanding of specialist referral for type 2 diabetes care with an objective to:

1. Determine the specialist referral rate for a population of patients with type 2 diabetes from 8 selected family practices in southwestern and central Ontario.

2. Determine the visit and patient factors associated with a referral to specialist care during a family physician visit with this same population of patients with type 2 diabetes.

Study Rationale

The Canadian healthcare system is based on a gatekeeper model to specialist care through referral from family physicians. An understanding of the relationship that exists between physicians and specialists, especially in the management of chronic diseases, may facilitate the design of a model that will promote effective resource utilization. Literature

examining the management of type 2 diabetes has primarily focused on the development of (15), implementation of (16) and adherence to (17) CPG's for family physicians, and comparing the outcomes of patients who were referred for specialist care to those who were not (18, 19). For example, it has been found that family physicians often experience clinical inertia (20) and may not be providing adequate care to their patients. Suggestions have been made that specialist care may result in better patient outcomes (20). These studies are integral in reporting the standard of care provided by physicians and specialists but are not adequate to assess improvements in the coordination of diabetes care.

Beyond supporting the governmental mandates described previously, our research may help in assessing access to and appropriate use of specialists, and highlight the need to define practitioner roles and responsibilities. Furthermore, our research may identify potential areas of intervention that may facilitate more effective resource use.

Our analysis will provide information on the characteristics of the visit and patient that result in a referral to specialist care. For example, if we see that elderly patients are more often referred, appropriate services could be implemented that would aid these patients in being able to attend their appointments. Furthermore, it may be possible to perform additional training or incentives to physicians to care for these particular patients in their practices instead of referring to costly specialist services.

Secondly, if research starts to address referral decision making, physicians may think more about the suitability of patient referral, and what their responsibilities are for follow-up. It may lead to a more clear distinction of the roles and responsibilities of family physicians and specialists in managing diabetes.

Finally, as mentioned, the CPG's are quite limited in their discussion of referral. The guidelines offer thresholds for when a treatment program should be initiated, so physicians may also benefit from the inclusion of threshold criteria for when to seek

specialist consultation. This additional advice may help to alleviate pressure on family physicians and specialists and help to define practitioner roles and responsibilities.

Canada's healthcare system is always changing, especially with respect to the availability of primary care physicians (PCP's) and specialists. It is important that we understand the interaction between primary and secondary care so we can ensure the stability and efficiency in the system.

Research has identified several factors that are associated with a referral to specialist care. Patient and physician demographics (21-25), patient morbidity (21, 24-27) and specialist availability (25, 28) are some of many factors identified. However, even when similar factors are found between studies, their associated direction of influence with referrals is contradictory. Moreover, specialist referral research for the population of patients with diabetes is much more limited. The research that does exist typically combines patients with type 1 and type 2 diabetes or focuses on specific populations such as veterans or newly diagnosed cases. Very few Canadian studies are available, and often suffer from the above limitations.

Chapter 2
Literature Review

Literature Review Strategy

The literature search began by highlighting the key words associated with the research question. Type 2 Diabetes, Referral, and Family Physician were the three key words identified. PubMed was used as the primary literature source for our research; SCOPUS and EMBASE were used as secondary sources.

Our three key words had the following MeSH (Medical Subject Heading) terms available:

1. **Type 2 Diabetes**
   a. MeSH: "Diabetes Mellitus, Type 2"
2. **Referral**
   a. MeSH: "Referral and Consultation"
3. **Family Physician**
   a. MeSH: "Physicians, Family"
   b. MeSH: "Primary Health Care"
   c. MeSH: "Family Practice"

These terms were advantageous because they found publications that may not have been given appropriate key word designations but had been classified under the relevant subject headings. All entry terms for each MeSH keyword were included in the search and '*' was used at the end of each term to capture key words with alternate suffixes.

The search strategy progressed in two stages. First, a narrow search was designed to assess the referral literature, specifically for the population of patients with type 2 diabetes.

Literature Search #1: [Physicians, Family] OR [Primary Health Care] OR [Family Practice] AND [Referral and Consultation] AND [Diabetes Mellitus, Type 2]

The literature captured in this search was quite limited. It revealed 127 items with the majority of the results offering little relevance to the research question. The search did however reveal general diabetes literature and publications discussing the clinical practice guidelines used in diabetes care.

Our second search broadened the field to include referrals from primary to secondary care in any disease area, not limited to type 2 diabetes.

Literature Search #2: [Physicians, Family] OR [Primary Health Care] OR [Family Practice] AND [Referral and Consultation]

The second search generated a whole host of literature, but was quite variable in relevancy. There were 1625 items. Relevant literature included studies looking at the history of referral research and referral studies in a variety of disciplines and patient populations such as hypertension, dialysis, and short stature in children. Additional literature was obtained by scanning the reference lists of the key papers from the two searches.

Canada's Health Care System

Canada's health care system is a publicly funded, universal health care system that offers health coverage to residents for any medically necessary hospital or physician service. A patient's health care is coordinated and managed by a family physician, with hospitals and clinics available for emergency or after-hours services. The family physician is most often a patient's primary health care provider and it is this relationship that facilitates access to the additional specialist health care services available in Canada (10). A PCP is a patient's primary medical resource with the responsibility of making "referrals when patients are in need of hospitalization, the services of other medical specialists or other

medical or paramedical assistant." (8) Therefore, the family physician acts as the "gatekeeper" of specialist services. This characteristic of Canada's health care system is in contrast to the health care systems of the US, France, Germany and Sweden, for example, which allow direct access to specialist care.

Many changes have occurred in the Canadian health care system over the past 10 years. New remuneration schemes have been introduced, the delivery of health care services is being changed and there has been devolution of health care policy and decision making from the provincial to regional level. Ontario, in 2006, established 14 Local Health Integration Networks (LHIN's) to better assess and address community level needs (29). The aim was to improve the efficiency and quality of health care services, a need driven by growing health care service demands.

Changes in physician payment schemes and the subsequent change in how healthcare services are provided have supported the national commitment to improving the organization of diabetes care. The remuneration scheme for physicians in Canada is based on either a fee-for-service (FFS) or a capitation system. FFS compensation involves physicians billing directly to the government for each service performed. Under this format, physicians have an incentive to maximize the number of office visits they have and the number of procedures they perform. A capitation system on the other hand involves the physician being paid a set salary for each patient that is cared for. The capitation system was introduced to support the governmental push for physicians to move to a more team based approach to providing health care. Under this scheme, physicians have an incentive to team up with specialists and other health care professionals to maximize the number and quality of services they can provide to their patients. Furthermore, the government offers bonuses to physicians who meet specific practice guidelines for patient care. A shift towards team based care was thought to ease a patient's navigation through the health care system and maximize the use of health care resources. These changes would be especially beneficial for patients with diabetes who often require care from multiple healthcare professionals.

Disparities exist between provinces in the percentage of physicians utilizing each of these payment models. In Ontario, as a result of training and education on the importance of collaborative and shared care (30), more physicians are moving towards capitation based compensation. In 2002/2003, 78% of physicians in Ontario were still FFS. In 2009, it was reported that "Ontario family doctors are shifting from fee-for-service to capitation in ever-increasing numbers" (31).

The push for collaborative care was also supported by the 2008 CPG's developed by the CDA. For example, the Canadian CPG's (7) advise that a core team be designed to include the family physician and/or specialist and the diabetes educators for optimal patient care. The CPG's also recommend that the "timing of referrals for self-management education should be based on the severity of presenting symptoms, the degree of metabolic control and the individual's understanding of immediate survival and safety skills and long-term management practice."(7) Beyond being in accordance with governmental policy, these guidelines are supported by research. The involvement of health care providers from a range of disciplines has been found to improve clinical outcomes (7). Properly managing diabetes depends on both the patient and the availability of an integrated diabetes health care team

Diabetes Health Care Services

For most patients, a decision to seek care from their family doctor is derived from the need for advice or management of a particular acute health problem, or from knowing the importance of annual physical exams. Type 2 diabetic patients on the other hand have a much greater set of conditions and concerns that need to be addressed on a more frequent basis. They are a distinct subset of the population who are several times more likely to see a healthcare provider, need homecare and be admitted to a hospital (7). Chronic Kidney Disease (CKD), neuropathy, retinopathy, obesity, cardiovascular disease and peripheral vascular disease (PVD) are common conditions among patients with type 2 diabetes. A patient's healthcare utilization is not only based on their own decision to seek care, but is also based on the guidelines that drive a physician's behavior in managing their patient's

disease. During a visit with their family physician, a patient may also gain access to additional physician services through referral to a specialist. Internists, endocrinologists, cardiologists, diabetes specialists, nephrologists, dietitians, podiatrists and ophthalmologists are common specialists and specialties that a PCP will refer a patient to for advice or consultation. A physician may also refer a patient to a DEC. These centers offer additional services to patients with diabetes for help with diet, lifestyle and smoking cessation.

Canada's diabetes CPG's have been developed and undergone several reiterations since 1992, with the most recent version available in 2008. These guidelines are a comprehensive view of the best practices in prevention, management and care of patients with type 1, type 2 and gestational diabetes. The guidelines are particularly important for family physicians, who are most often the coordinators of care for patients with diabetes (10). Our discussion will be limited to an analysis from the perspective of the family physician and will consider patients who are under their care.

It is very common for family physicians to seek consultation, treatment advice or help for either short term or long term diabetes care. **Table 1** summarizes the current recommendations and guidelines that dictate a patient's utilization of health care services for diabetes related circumstances. There are several instances in the diabetes CPG's where referral recommendations for a specific aspect of patient care are not made. Therefore, referral decisions are subjective in nature and can be influenced by a variety of factors. Variability in referral decision making is evident within and among physician practices.

Specialist Referral

There is literature that suggests that individuals with diabetes may benefit greatly from specialist care. Shah et al (32) in 2005 compared glycated hemoglobin (A1C) of patients with diabetes who received specialist care against those who received only primary care. They found that referred patients had a lower A1C, and therefore better glycemic control

Table 1: Recommendations and Guidelines for Diabetes Health Care Utilization

Area of Concern	General Recommendations	Referral Considerations
Self Management Education	An education program should be created for every patient, tailored to their needs.	No referral recommendations.
Monitoring Glycemic Control	When targets are not met – measure A1C levels every 3 months. Otherwise, measure every 6 months.	No referral recommendations.
Physical Activity	A physical activity plan should be created for every patient after considering susceptibility to injury.	Mentions that another professional could be involved in the development of a plan.
Nutritional Guidelines	Specific recommendations mentioned, including carbohydrate restrictions.	Nutritional counseling by a registered dietician is recommended.
Pharmacological Management of Insulin	After 2-3 months, if glycemic levels are not achieved, an antihyperglycemic pharmacotherapy should be started.	No referral recommendations.
Obesity	A lifestyle management program should be implemented; a pharmacologic agent and bariatric surgery should be considered. Insulin therapy should be considered for A1C's>9.0%.	No referral recommendations.
Psychological Care	Regularly screen for psychological distress. Multidisciplinary team members should have experience to offer stress management and coping skills training.	No referral recommendations.
Influenza and Pneumococcal Immunization	Patients over 65 years of age should have a one time revaccination for pneumonia.	No referral recommendations.
Complimentary and Alternative Medicine	Patients should be asked if they are using any of these options.	No referral recommendations.
Intervention of Coronary Events	Physicians should periodically screen their patients.	No referral recommendations.
Screening of Coronary Artery Disease	Physicians should periodically screen patients who are at high risk.	Stress testing recommended. Typically done by an internist or cardiologist.
Vascular	Prevention of macrovascular	No referral

protection	complications should come from lifestyle and pharmacological management on a case by case basis.	recommendations.
Dyslipidemia	The primary target is appropriate LDL levels, and the secondary target is TC:HDL levels. These tests should be ordered every 1-3 years or more as appropriate.	No referral recommendations.
Treatment of Hypertension	People with elevated blood pressures should be aggressively treated to prevent micro and macrovascular complications.	No referral recommendations.
Management of acute coronary syndromes	Be careful when treating because renal dysfunction may be more prevalent in diabetics and may influence heart failure drug doses.	No referral recommendations.
Chronic Kidney Disease in Diabetics	Requires screening for proteinuria as well as an assessment of renal function. Should be screened annually. People with diabetes and CKD should have eGFR measures every 6 months.	A referral to nephrologist or internist should be considered if there is chronic and progressive loss of kidney function.
Retinopathy	Requires regular screening depending on age and type of diabetes. Recommended to be screened every 1-2 years	Screening should be performed by experienced professionals. Visually disabled people should be referred for low-vision evaluation and rehabilitation.
Neuropathy	Neuropathy screening should be performed annually. It can be performed quickly and easily.	Referral should take place for additional evaluations if there is suspicion of neuropathy.
Foot Care	Should be screened annually or more if at high risk	Early referrals to a healthcare professional trained in foot management should take place if problems occur.
Erectile Dysfunction	Men should regularly be screened.	Referral should be considered or provided if fertility is required.
Diabetes in the elderly	Treatment is handled differently.	They should be referred to interdisciplinary intervention centers for education and support.

Note: Adapted from the 2008 Canadian Diabetes Clinical Practice Guidelines (7).

than those patients who were not referred. Specialist care appeared to have an impact on patient health outcomes. They also found that the referred patients were younger, lived in wealthier neighborhoods, had a longer duration of diabetes, more complications and were more likely to live in urban areas. Moore et al in 1998 (33) identified the characteristics of patients attending a referral clinic versus a primary care clinic, with specific interest in whether or not hypertension was present. More patients, who were referred had hypertension, had a longer duration of diabetes, were older, on insulin, on higher insulin doses, and were more likely to have coverage with Medicare or Medicaid. The two populations did not to differ by age of diabetes onset, body mass index (BMI) and systolic or diastolic blood pressure. These two studies are instrumental in showing that patients who are referred differ significantly from those who were not referred. The variability in results indicates the subjective nature of specialist referral and highlights the need for physicians to accurately identify those patients who will benefit from specialist services.

Research assessing the physician referral process is not new. Several frameworks have been developed over the course of referral research history that attempt to model the interaction and coordination of care between physicians. Early research on referrals derived principal ideas from the social exchange theory developed by Homans, Thibaut, Kelley and Blau. Shortell and Anderson (34) were the first to discuss the use of this model for conceptualizing the referral interaction. Prior to this there was no theoretical basis for analyzing and assessing referral practices.

The social exchange theory uses an economic and social psychology approach to the discussion of relationships between individuals in society. In terms of interacting physicians, it is based on the idea that physicians will refer patients to each other if it is believed that a positive outcome will result. A positive outcome occurs when the rewards of referral are greater than the costs that it incurs. Shortell (35) uses this model to contextualize the discussion of the determinants of physician referral rates. A population of 146 internists in select Chicago suburbs underwent in-depth interviews and agreed to a 2-week collection of referral verification forms at their practice site. The dependent variables included the rate of incoming referrals, outgoing referrals, and health agency

referrals. A referral occurred when "one physician transfers responsibility either temporarily, permanently, or for part of a patient's care to another physician." (35) The independent variables of interest were the physician's professional status and the level of satisfaction with referral partners. Professional status was based on a composite score of seven variables. It included measures such as number of leadership positions, publications and presentations and a self evaluation of his or her own professional status. Satisfaction was based on a score derived from five satisfaction questions including: communication, quality of care, and reciprocation of referral. Physician competence, practice type, volume of practice, years in practice, percentage of low-income patients and caseload severity were controlled for in the analysis. As predicted by the theory, results indicated that general physicians with the highest professional status score received the greatest number of referrals. It was also found that greater caseload severity, a greater number of office visits per week and having a solo practice resulted in a lower outflow referral rate. These findings were unexpected. Twenty-two percent of the variance in referral rates from generalists to specialists was explained by the exchange theory and practice level variables.

Research was then broadened to assess referral rate differences between specialties. The theory adopted to conceptualize this research was Freidson's Classification of Medical Specialties. Freidson states that medical specialties lie on a continuum from client-dependent to colleague-dependent in how they attract patients. Client–dependent specialties such as internists and general practitioners are highly dependent on patient self-referral to receive patients whereas colleague-dependent specialties such as radiologists or surgeons are more dependent on physicians to receive patients. Therefore, Shortell and Vahovich (28) hypothesized that generalist physicians will be more susceptible to patient characteristics in their decision to refer. The sample included 1,393 U.S. physicians specializing in family practice, internal medicine, surgery, pediatrics or obstetrics-gynecology. The referral rate was self-reported by physicians and was defined as the "percentage of patients referred to other physicians, whether inside or outside the respondent's practice." Patient and physician variables, as well as specialist availability were included in the model. The results indicate that physicians who practice in a group setting, have higher office visit fees and have more specialists available in their region

refer a greater number of patients. It was also found that physicians with a larger percentage of their patient population over 65 years of age have a higher referral rate. Only 17% of the variance in general practitioner referral rates was explained by the model. Physician variables were found to be more important than patient variables in the decision to refer.

As referral research moved into the 1990's, Gonzalez and Rizzo (36) highlighted the importance of discussing the context in which referrals take place, the medical marketplace. They assessed referral practices from the perspective of the specialist that the patient is being referred to. Their research focused on the number of patient visits that were the result of a referral received from another physician, but they also highlight factors associated with referral. The number of physicians in the county, per capita income, and practice arrangement were thought to have an influence on referral rates. Results for referrals to specialists indicate that specialist supply does not influence referral rates. They propose that this is due to the fact that most specialist referrals are not elective. However, their study does not appear to take into consideration patient case-mix.

Recent studies combine these early theories to produce research aimed at determining the patient, physician and health care system determinants associated with the decision to refer. Several studies (21-23, 26, 27, 37-43), and a critical literature review by O'Donnell (44) in 2000 all analyze the effect of these three levels of factors on referral decisions. A selection of the listed studies is described in the subsequent section.

There have also been recommendations in the literature that stress the importance of establishing a clearer definition of the PCP's and diabetes specialist's responsibilities in patient care (33). Understanding the factors that are associated with specialist referral will identify certain characteristics that lead to PCP's referring their patients and what combination of factors lead to the transfer of responsibility from a family physician to a specialist. The assortment of literature assessing the determinants of specialist referral does not reveal a collective depiction of the strongest predictors of referral. Results are often contradictory between studies. However, comparisons are often difficult because of differing research questions, patient populations and methods of analysis. The

determinants of specialist referral in a more general population are first discussed, followed by a narrowing of the patient population to patients with diabetes and finally to patients with diabetes in the Canadian context.

Determinants of Specialist Referral

As previously mentioned, research that addressed specialist referral typically modeled the decision to refer against patient, physician and community or health system variables. Each study differed in which variables were included and assessed in the model. The most popular type of model included factors from all three categories (21, 26, 37, 43, 45), while others focused on one or two categories of interest (22, 46-49).

Chan et al (26) examined determinants of referral for a sample of the general patient population of Ontario (696,003 patients) using the Ontario Health Insurance Plan claims database in 1997-1998. A referral was defined as "an outpatient consultation, limited consultation or repeat consultation performed by a physician on a patient, at the request of the patient's customary PCP." The unit of analysis was the individual patient, and there was an average of 0.56 referrals made per patient during the year. Multilevel generalized linear models were used to assess the patient, physician and community characteristics on the likelihood of referral. Patient age, gender, income and case-mix as well as physician gender and community characteristics were all predictors of referral. Increasing patient age, being a female patient, having an income greater than $80,000 or having a large number of disease conditions were associated with a greater chance of referral. Additionally, being in a community with a medical school, in an urban center or with a female physician also resulted in a greater likelihood of a specialist referral. The results may be underestimating the actual number of referrals made by the PCP because a referral is included only if the patient had a visit with the referred specialist.

While Chan et al (26) found a combination of patient, physician and community level variables significantly associated with referral, the next few studies highlight the importance of patient variables and co morbidities in predicting specialist referral. Forrest

et al (21, 27, 50), in the U.S., examined referral patterns based on a log of patient visits over 15 consecutive days. To study the determinants of referral, 142 Physicians from 83 practices were recruited through the Ambulatory Sentinel Practice Network, other research networks and the wider physician community (21). Data was collected from physician surveys, the logbooks of the practice sites, and from the questionnaires completed by physicians after each referral. The unit of analysis was the patient visit. Patient, physician and health care system factors were modeled against the dependent variable, any referral, using a generalized linear mixed model accounting for multiple visits per physician. A referral was defined as "a physician's decision to send the patient to see a specialist practitioner for a face-to-face encounter" and were limited to those that occurred during an office visit. Forward and backward variable selection methods were used. The referral rate (number of referrals/number of visits) was 5.2% and researchers discovered that patient characteristics had the largest effect on referral decisions. The patient characteristics that were found to be associated with a greater likelihood of referral included: male gender, over 17 years of age, access to health insurance, high burden of co morbidity cared for during the visit, and presenting problem not typically cared for by the physician (21). There were fewer physician and health care system determinants that influenced referral but those that were associated with a greater likelihood of referral included: solo practice, higher number of years in practice and greater number of specialists in the community. Their earlier study (27) is based on the same population of physicians but focused on the reasons for referral and the types of conditions referred. The referral rate per visit was 5.1% and it was stressed that the type and severity of a patient's clinical morbidity is a very important determinant of referral.

In another U.S. study, Franks and Clancy (43) were also interested in finding the patient, physician and practice factors that were associated with an adult patient referral. The sample included 49,738 visits using data collected from the National Ambulatory Medical Care Survey for 1985 and 1989-1992. A complex sampling procedure, stratifying physicians by county and specialty, was used to obtain a probability sample of office visits. The dependent variable was whether or not a referral took place at the end of the patient encounter. Independent variables included patient demographic and disease

variables, physician demographic variables and practice related factors. A patient record was completed by the physician after each visit. This information as well as additional physician information derived from the National Center for Health Statistics comprised the dataset. Similar to Chen et al (46), the unit of analysis was the patient visit, and SUDAAN software was used to control for the clustered sampling procedures. The referral rate per visit was 4.5%, and multiple logistic regression generated a collection of significant predictors of referral. Patients who were male or who had insurance coverage were more likely to be referred. Likewise, visits with female physicians or more general practices were more likely to result in referral. Shorter visits, presenting problems having been addressed at a previous visit and a patient having fewer medication prescriptions were associated with a greater likelihood of referral (43). Age and race were found not to be associated with referral, similar to what has been found in other studies (21, 22, 46).

Shea et al (37) found that excellent health status, fewer disease conditions, lack of insurance, low income and little education resulted in a lower probability of referral. Where previous research had focused on the general population and encounter specific surveys, this study narrowed the population of interest and used not only claims data, but also patient surveys to obtain additional variables. The sample population used was 4,700 and 5,200 Medicare beneficiaries in the US during 1992 and 1993 respectively. Due to data limitations the number of visits and number of referrals recorded were from different years. There were 40,316 generalist visits in 1993 and 4,061 referrals in 1992 resulting in a referral rate of 10.1%. A referral rate in this case was defined as the "ratio of specialist referrals to primary care visits." Unlike comparable research, patient gender and several physician factors were not found to be significant.

Even though each of the studies above discussed the importance of assessing the patient, physician and community level variables associated with referral, their results indicate that patient factors (age, gender and income) and a patient's burden of morbidity may be the most influential. Shea et al (37) found that physician factors did not offer much variability but stated that patient factors are more important in determining specialist referral. Similarly, Forrest et al (27) highlighted the importance of patient variables and

their associated morbidities on specialist referral. It is also interesting to note that Franks and Clancy (43) highlighted a visit level variable that may be influential on specialist referral – the length of the patient visit.

The next set of studies highlight one or two sets of variables having an influence on specialist referral. Iverson et al (48) were most interested in the effect of physician variables, Cowen et al (22) were interested in patient and physician variables, and Chen et al (46) focused on patient variables and co morbid conditions.

Since referrals are typically at the discretion of the physician, especially in Canada's gate keeping arrangement, researchers often assess predictors of referral at the level of the physician. Iverson et al (48) mailed surveys to 1200 randomly selected physicians in the US to identify their age, sex, gender, training, experience, practice site, and self-perceived referral rate to specialty physicians. A larger practice site population was associated with a greater likelihood of referral. All other factors including physician factors were not significant. Patient case-mix was not considered in the analysis.

Cowen et al (22) hypothesized that a referral decision would be driven by patient and PCP characteristics. The study population included 114 primary care physicians in southeastern Michigan during 1996. The researchers assessed referrals made to one of five specialties (cardiology, ophthalmology, pulmonary disease, orthopedics and general surgery), and also used physician questionnaires after each referral. The unit of analysis was the patient visit, and a referral was defined as "a face-to-face encounter with a specialist" within 90 days of a primary care physician encounter. The definition of referral used in this study was comparable to Chan et al (26). It captured only those referrals for which the patient actually sees the specialist within 90 days of the principal visit. This definition of referral was different from most studies reported in the literature, but still found that patient and PCP characteristics were associated with referral. Patient medication, age, and diagnoses, and physician age and years out of medical school significantly influenced referral decision making. The size and direction of the effect was dependent on which specialist the patient was being referred to (22). For example, for

ophthalmology referrals, the odds of referral increased with patient age, when the visit was for an eye problem, and for increasing physician satisfaction. The odds of referral were lower for physicians who had been out of school for a longer period of time.

Chen et al in 2005 (46), highlighted the wide variation in specialist referral rates that have been documented in the literature as a consequence of patients co morbid conditions, health status and demographics as well as provider and system level factors. The researchers were interested in assessing the influence of patient characteristics and co morbidity on referral decision making. Their sample population included 9 clinics of the University of Washington Physicians Network which included 251,240 patient encounters and 23,720 referrals during 1999. Dependent, independent and control variables were obtained from the electronic health record system that was employed by the network. The unit of analysis was the patient visit and a referral was defined as "an encounter that resulted in a consultation to another physician for specialty care." This study uses a similar definition of referral to that used by Cowen et al (22) and Chan et al (26). The analysis was performed using SUDAAN software to account for the clustering of physicians in the same clinic and patients with the same physician. The referral rate was 9.4%. This study supported male tendency to be referred more often than females, but challenged Forrest's (21) findings for age. Patients aged greater than 65 years and less than 18 years were less likely to be referred, as were patients of a minority race. The presence of co morbid conditions was related to greater odds of referral.

Similar to the group of studies that model specialist referral against patient, physician and community level variables, the previous three studies also found that patient variables (age, gender and race) and co morbid conditions are the most influential factors

The next set of studies relates to specific populations and discusses the determinants of referrals to specific specialist physicians. Campbell et al (23) highlights variables related to the patient-PCP relationship as important factors associated with specialist referral while Nguyen et al (47) discusses the characteristics of a patient population attending a

DEC centre. The variability in specialist referral practices between countries is then addressed.

Johnson et al (49) and Campbell et al (23) assessed predictors of referrals to urologists and nephrologists respectively. Johnson et al's (49) objective was to identify the factors that influence patient referral to an urologist for hematuria evaluation. The unit of analysis was the patient and involved a population of 926 adult patients in the Midwestern US who were newly diagnosed with hematuria. The researchers found that referral to an urologist was more likely with increasing patient age, male gender, a greater number of family physician visits and a greater number of referral visits. Campbell et al (23) in 2008 performed a literature review of studies that assess physician decision making for nephrologist referrals for patients suffering from CKD. They propose a conceptual model for the referral decision pathway, and highlight directions for future research. Their review encompassed research from countries around the world including Canada, Ireland and the US. The conceptual model they proposed stressed the importance of patient factors (disease specific, symptoms, demographics and preferences), patient-physician relationship factors (duration of relationship, frequency of visits and trust in physician) and physician factors (experience, knowledge and demographics) in the referral decision.

Nguyen et al (47), also in the US, found that in a Veterans Diabetes Clinic patients were typically male, had poor glycemic control, an average body mass index of 31.3kg/m^3, average A1C of 9% and average age of 60 years. This research is instrumental in secondary health resources planning as they were able to define the target population who need health services. Resources at the veteran's clinic should be targeted for males with a mean age of 60 years, an elevated A1C, overweight, a high level of co morbidities and who have difficulty controlling their blood sugar. However, the study has limited generalizability as it is restricted to the veteran patient population.

The Netherlands, UK and Lithuania have also assessed referral practices for the general patient population in their respective countries. It has been found that referral rates vary significantly between countries (51). Sullivan et al (24) in 2005 assessed the impact of a

patient's morbidity in explaining variations in referrals to specialist care. The study was based in the UK. The UK is a country that, like Canada, defines a general practitioner as a "gatekeeper" to specialist care services and therefore offers more comparable results. The researchers used multilevel modeling techniques to assess patient age, sex and morbidity on the likelihood of referral. The sample consisted of 1,323,611 patients from 211 practices in England and Wales during 1997. The unit of analysis was the patient, and during the study period 14.7% of patients had at least one referral. The amount of variation explained by the model was greatest when patient age, sex and morbidity were included. Female patients, patients aged 15-64 and those who were least healthy had the greatest odds of referral, but much of the variation remained unexplained at both the patient and the practice level. Zielinski et al (52) also found that female gender and higher morbidity was associated with greater odds of referral. Likewise, referral was greatest for patients 20-39 years of age. The study was based in Lithuania and focused on assessing differences in referral rates between four types of primary health care models. The population consisted of 18 practices with a total of 250,070 patients in 2005. The unit of analysis was the practice, and involved Poisson regression analysis modeling number of referrals/1000 patient years by type of practice and patient variables. In addition to the aforementioned significant variables, rural practices were found to have lower rates of referral compared to urban practices. Delnoij et al (45) limited their research to only referrals that were made to internal medicine specialists. The population consisted of all patient visits (387,250) during a 3 month period in 1987 from 102 practices in the Netherlands. A logistic regression model was used to assess the influence of patient morbidity and patient, physician and system variables on the likelihood of being referred. Female patients, patients of greater age or patients having private vs. public insurance decreased the chance of referral. Furthermore a referral is more likely for a patient with a greater number of complications or a physician with a larger patient population. Patient age, gender and morbidity were all predictors of referral in each of the three countries listed above (45, 52, 53), however the direction of influence was inconsistent.

Determinants of Specialist Referral for Patients with Type 2 Diabetes

Outside of Canada, research on specialist referral for patients with type 2 diabetes is quite limited. Two studies in the US assessed type 2 diabetes patient referrals to eye care specialists (54, 55). Lazaridis in 1997 (55) reviewed the use of optometrist and ophthalmologist referrals for patients with type 1 and type 2 diabetes. The sample population was 931 physicians from Indiana in the U.S. during 1993. Data collection methods included census data and a physician questionnaire. It was found that 10% of the patients with type 2 diabetes were referred to an optometrist while 90% were referred to an ophthalmologist. Although this research revealed high use of ophthalmologist services by PCP's for patients with type 2 diabetes it did not compare the characteristics of patients who were referred vs. not referred, and used a physician questionnaire to determine referral use. The unit of analysis was the PCP. The analysis does not revolve around the decision to refer, but instead looks at the probability of being referred to an optometrist vs. an ophthalmologist. Of those patients referred for eye care, nine times out of ten they were referred to an ophthalmologist, but it is unknown what proportion of diabetic patients actually receive specialist care, and how they differ from those who are not referred. This research may be more relevant for resource planning purposes.

Wylie-Rosett et al (54) were interested in assessing the determinants of ophthalmologic referral for patients with diabetes who were located in one of four disadvantaged communities of New York City. The sample consisted of 350 reviewed patient charts. Stepwise logistic regression analyses were used to predict a patient's referral status. The presence of eye disease and if the patient was on insulin therapy were significant predictors of referral.

Determinants of Specialist Referral for Patients with Diabetes in Canada

Research assessing specialist referral for patients with type 2 diabetes does exist in Canada. Patient, physician and community variables were assessed in a study by Reid

(25) while Shah et al (32) focused on assessing the characteristics of patients who were selected for specialist referral. Additionally, there are many studies in Canada that have assessed the characteristics of patients attending DEC's. These studies highlight key laboratory measures or visit level factors that are likely to influence whether or not a patient is referred to specialist care.

A study of referral patterns in Alberta Canada (25) provided an analysis of the longitudinality of care for patients with diabetes. It examined the frequency of care, routes to obtain specialist care, how specialist care is used over time, and the coordination of care between generalist and specialist. Referral was defined in this study to include primary care referral, self referral and cross referral (specialist to specialist).The study population was 4,577 patients with type 1 and 2 diabetes who had been diagnosed with diabetes within the previous one and a half years. Patients were identified from the Alberta physicians claim database in 1994. The unit of analysis was the individual patient and the specialists included were only those who provided diabetes related care. Multivariate logistic regression was used to assess the influence of disease, patient, generalist and medical system factors on the likelihood of a patient being referred for specialist care. The definition of referral for this particular research question excluded patients who self-referred or were cross-referred for specialist care. Referral to a specialist was associated with patient age, case-mix, geographical access to specialist care and physician gender, age and experience. Patient age was inversely associated with referral. Older patients were less likely to be referred compared to those patients in their 60's.Younger patients, likely those with type 1 diabetes, had a much greater likelihood of referral than those patients in their 60's. The greater morbidity a patient suffered from and if they lived in a rural area, the more likely they were to be referred. Patients with a male physician or a physician with more medical experience were less likely to be referred. This research is advantageous for understanding a diabetic patient's full spectrum of care, and supports the Canada Health Act mandate to ensure that accessibility of care be based on medical need. These results, however, are difficult to apply to our research question because they include patients with both type 1 and 2 diabetes, are limited to newly-diagnosed patients with diabetes and use the patient as the unit of analysis. The results

may overestimate resource use because they include only newly diagnosed patients. Furthermore, patients with type 1 diabetes and patients with type 2 diabetes are separate groups that require different types of medical care. The determinants of referral to specialist care may differ between the two groups. Although advantageous for resource planning and recommendations for the coordination of care, this study may not provide an accurate picture of specialist use by patients with type 2 diabetes alone.

In Ontario, Shah et al (32) used the Ontario Diabetes Database, discharge abstracts database, the doctor service claims database and the Database of Laboratory Tests in Eastern Ontario (DOLTEON) to assess the characteristics of patients selected for specialist referral. The sample population consisted of 3,533 patients with diabetes in eastern Ontario between September 1999 and September 2000. Someone having specialist care was defined as such if they had had a specialist visit "at least two other times between 2 and 24 months prior to the index visit". Otherwise, they were placed in the primary care group which was patients that had seen their PCP at least two times during that same time period. Younger age, greater income, longer duration of diabetes, a greater number of complications and co morbidities, and living in an urban setting were significant predictors of receiving specialist care. However, similar to Reid et al (25), this study did not differentiate between patients with type 1 and 2 diabetes.

Like Reid (25), Rabi et al (56) assessed patient referrals in Alberta. These referrals however, only included ones to a DEC. Using the National Diabetes Surveillance System and census data researchers found that 14% of 4,247 patients with type 2 diabetes were referred to a DEC. The unit of analysis was the individual patient and Poisson regression was used to determine the influence of demographics and socio-economic status on the likelihood of referral. Increasing patient age was the only significant predictor.

DEC's in Alberta Canada have been the centre of much analysis on patient healthcare utilization and referral rate (56-58). Whereas Rabi et al focused only on patients with type 2 diabetes, Fernandes et al (58) identified 1,459 type 1 and 2 diabetes patients attending a Calgary DEC from June 1, 2000 to August 31, 2000. These patients had either single or

multiple referrals to the DEC by their family physician and were experiencing suboptimal control of diabetes, poorer glucose control, and tended to be younger. Other independent variables recorded included: blood pressure, A1C, albumin/creatinine ratio (ACR), triglycerides, total cholesterol, high-density lipoprotein (HDL) and low-density lipoprotein (LDL) (58).

Two studies (59, 60) evolved from a Toronto DEC. Similar to Rabi et al (56, 57) and Fernandes et al's (58) use of Alberta DEC centers, the Toronto studies focused on patient factors related to the use of these services. Those patients with ongoing use of the DEC centers tended to be more often female, smokers, live closer to the centre, have a longer duration of diabetes, be employed and have higher BMI's compared to their counterparts who had high levels of attrition.

Similar to research outside of Canada, specialist referral research in Canada, as mentioned, has also found that patient variables such as younger age and living in an urban area as well as a higher burden of morbidity result in a higher likelihood of referral. The research also highlights that laboratory measurements or visit level variables, such as A1C, ACR and BMI may help distinguish between patients who are referred versus patients who are not referred.

As is seen throughout the referral literature there are several inconsistencies in the identification of variables that are found to be significantly associated with referral. For example, inconsistencies are seen when comparing results from Rabi et al (57) and Fernandes et al (58). Rabi et al (57) notes that patients referred to DEC centers tend to increase with age whereas Fernandes et al (58) cites the opposite. However, both researchers note that the triggers for referral remain to be addressed (58), and the threshold for referral warrant further examination (57).

Gaps in the Literature

The literature described indicates that there is a need to understand and define the roles of general practitioners and specialists (33), the triggers of referral (58) and to further examine thresholds for referral (57) in providing diabetes care. To support this need it is important to identify the factors that are leading physicians to request specialist advice and consultation. These factors will paint a picture of the set of conditions sufficient to result in specialist referral following a patient-PCP encounter.

The application of social exchange theory to referral decision making by Shortell (35) in 1974 spawned a collection of research aimed at discovering the determinants of referral. The studies discussed in the previous sections highlight the progression of research since then. Chan et al (26)(46)(46) and Forrest et al (21) identified the determinants of specialist referral for the general patient population in Canada and the US respectively. Similarly, US studies by Chen et al (46) and Franks et al (38) had comparable aims and objectives. However, no studies were found that contained all the elements appropriate to our research question: patients with type 2 diabetes, practices from southwestern and central Ontario, visit level factors and the patient-PCP encounter as the unit of analysis.

Chan et al (26) identified the determinants of referral for the general patient population in Ontario in 1997-1998. This research provides a model for conceptualizing referral decision making, but the analysis is carried out at the patient level and defines a referral as such only if the patient actually consults the referred specialist. This may not provide the most accurate interpretation of factors associated with referral because the decision to refer is made at a patient-PCP visit, where factors such as lab values – A1C, ACR, triglycerides, and cholesterol can vary from visit to visit within the same patient. By analyzing referrals based on the characteristics of the patient that are constant we may be missing out on factors that are more proximate to the physicians decision to refer, such as the lab measurements that are taken at the specific visit.

A study in the US by Cowen et al (22) was focused on describing the most appropriate methods for assessing referral patterns. In contrast to Chan et al (26), the researchers highlighted the importance of analyzing referrals at the level of the patient-PCP

encounter. A referral had the same definition as Chan et al (26), being recorded only if the patient actually consulted the referred specialist. This is a suitable definition for resource planning purposes but it may underestimate the number of referrals that a physician is actually making; not all patients will comply with the recommendations made by their physician.

Franks et al (43) and Forrest et al (21) studied the determinants of referral in the US using the visit as the unit of analysis and a more suitable definition of referral. A referral included all cases where a physician recommended that a patient consult a specialist. Physician surveys were filled out by the appropriate physician after each visit. This method of data collection is valuable because it is targeted directly at the physician making the referral, however, it may be subject to social acceptability bias. Physicians may write down things that they believe people want to hear. Alternatively, Chen et al (46) had access to an electronic health record system from the University of Washington Physicians Network. The researchers used the patient-PCP encounter as the unit of analysis, but had a definition of referral that suffered from the same limitations as in Cowen et al (22) and Chan et al (26).

The patient populations for Reid (25) and Shah et al (32) were only patients with diabetes, with Reid et al (25) including only newly diagnosed cases. In both studies, the population included patients with both type 1 and type 2 diabetes. However, patients with type 2 diabetes are a special group of individuals that require a different combination of services compared to their type 1 counterparts and should therefore be treated as separate populations.

Studies that include only patients with type 2 diabetes are those that provide a description of the patient population attending DEC's. Nguyen et al (47) focused their analysis on a US veteran DEC centre, Rabi et al (56) on an Alberta DEC, and Gucciardi et al (60) on a Toronto DEC. These studies described the patient population attending the clinics by A1C, ACR, blood pressure, weight, triglycerides and cholesterol measures. These studies do not have a non-referred comparison group and have limited generalizability because of

their narrowly defined population. In studying only the population that is attending the DEC centers, we are also unable to see who it is that physicians are referring that don't even end up making it to the DEC centre.

In studies that do assess the determinants of specialist referral, there are definitely inconsistencies in the findings. Some studies find certain predictors significant but others do not. In a literature review by O'Donnell (44) from 1970-2000, it was found that the variation in referral practices remains largely unexplained with patient, physician and practice characteristics explaining no more than half of the observed variation.

The present compilation of literature does not specifically address the visit and patient factors associated with specialist referral for the population of patients with type 2 diabetes in southwestern and central Ontario. As demonstrated, it is common for research to combine the populations of patients with type 1 and type 2 diabetes, cover only a limited time frame and use only patient, physician and community related variables. The present study benefits from four and a half years of patient visits, a large amount of clinical data, and a population of only patients with type 2 diabetes. Limiting the population to only individuals with a particular disease may be beneficial because it has been noted that primary care physician's referral rates exhibit some stability within a specific disease category (38).

Our study aims to contribute to the understanding of specialist referral in the context of type 2 diabetes, with an objective to:

1. Determine the specialist referral rate for a population of patients with type 2 diabetes from 8 selected family practices in southwestern and central Ontario.

2. Determine the visit and patient factors associated with a referral to specialist care during a family physician visit with this same population of patients with type 2 diabetes.

Chapter 3

Methods

The literature review identified several gaps in the research related to specialist referral for patients with type 2 diabetes. There is a large amount of discrepancy as to what variables to assess in understanding referral decision making and the direction of influence. The determinants of specialist referral in southwestern and central Ontario for the population of patients with type 2 diabetes in particular have not been researched.

Objectives

The present study is relatively exploratory in nature, but aims to help fill the gaps in the literature by identifying the visit and patient factors that are associated with a referral from primary to secondary care for the stated population. What factors contribute to a PCP's decision to refer a patient, during a patient–PCP encounter, to a specialist? Few researchers have considered the effect of visit level factors on a physician's decision to refer.

Specifically, our research will:

1. Determine the specialist referral rate for a population of patients with type 2 diabetes from 8 selected family practices in southwestern and central Ontario.

2. Determine the visit and patient factors associated with a referral to specialist care during a family physician visit with this same population of patients with type 2 diabetes.

Original Study

The data for the present study was derived from data collected for a previous diabetes intervention study. The original study was designed to assess the impact and cost-

effectiveness of point of care (POC) testing for diabetes management in the family practice setting. It was a randomized controlled trial of 8 family practice groups in southwestern and central Ontario, with 34 physicians and 396 consenting patients. Intervention involved introducing two devices into family practice groups: a Clinitek 50 to screen for nephropathy by measuring the ACR and a DCA2000 to measure A1C. The intervention lasted for 12 months periods between February 2001 and October 2003.

The primary objective was to determine whether the intervention group experienced a change in ACR and A1C levels. Secondary objectives included determining patient perspective on physician communication, patient adherence and cost effectiveness. The study produced a very rich data set with an emphasis on clinical data. It involved multiple questionnaires including: health status using SF-36, physician practice and knowledge, POC technology assessment and patient communication.

Data relating to ACR had been analyzed, indicating no change in nephropathy diagnosis between groups. However, among the secondary objectives, many significant trends have been found. These include a statistically significant increase in the number of referrals and visits to a diabetes specialist. The wealth of clinical data available from this dataset was thought to be invaluable in discovering what factors contributed to the change in the number of referrals made.

Population

The sample size selected was appropriate for detecting a 10% change in A1C levels accounting for clustering within each practice and lost to follow-up. The selection process was based on the eligibility criteria outlined in **Table 2**.

The investigator first contacted one family physician from the eligible practices. The aim was to determine interest. Information was then sent to the practice and a meeting time set up. A letter of information and consent was then read and signed by physicians. Clinical support staff was also recruited. A listing of patients with type 2 diabetes was then received from each physician and eligible patients were sent a letter of information and

Table 2: Sample Eligibility Criteria.

Practice Eligibility	**Physician Eligibility**	**Patient Eligibility**
Location: Southwestern Ontario **Group Size**: 4-6 physicians **Experience**: No recent participation in diabetes studies **Physicians**: Must be eligible	**Status**: Full time (>=20 hrs/week), non-academic **Patient Population**: Must provide primary care management to patients with type 2 diabetes **Requirement**: Must be able to provide a list of potential patients	**Diabetes Diagnosis**: Diagnosed at least one year prior to baseline study period **Interaction with FP**: Has seen the family physician within the previous 12 months **Demographics**: 18 years or older **Pregnant**: No pregnancy in the past 24 months **Other**: Competent to consent

consent form. The final sample included 8 family practice groups, 34 physicians and 396 patients. The locations of the eight family practice groups are depicted in **Figure 1**.

Data Collection

For the purposes of this study, only the relevant dates and questionnaires and auditing procedures will be discussed. Data were collected through a series of patient and physician questionnaires and a comprehensive chart review.

May 1, 1999 – April 31, 2000 was selected as the baseline or reference year. A variable lag time between the baseline year and the intervention period allowed for investigators to obtain consent, send baseline surveys to patients and physicians, randomize practice sites, and conduct the continuing medical education (CME) session. The start and end of the intervention varied between practice sites, but was consistently one year in length and fell between February 2001 and October 2003. During the intervention period, two additional questionnaires were sent out, including a communication questionnaire. Post-Intervention consisted of a final post-intervention survey package for patients and the auditing of patient charts. Please refer to **Appendix A** for a detailed study timeline.

The baseline physician survey was a general demographic self-report survey. It asked for information such as graduation year, level of interest in diabetes, age, gender and training institution. The patient baseline questionnaire was also self report and contained several components: general demographics, adherence, treatment satisfaction and health status. Chart auditing focused on two time periods: Pre-May 1, 1999 and Post May 1, 1999. Before May 1 1999, auditors recorded conditions and diagnoses, referrals, medications (1998 onwards), examinations of dilated pupils (1995 onwards) and smoking status. After May 1, 1999 auditors recorded all patient visits, laboratory results, conditions and diagnoses, referrals, medications, eye examinations of dilated pupils and smoking status.

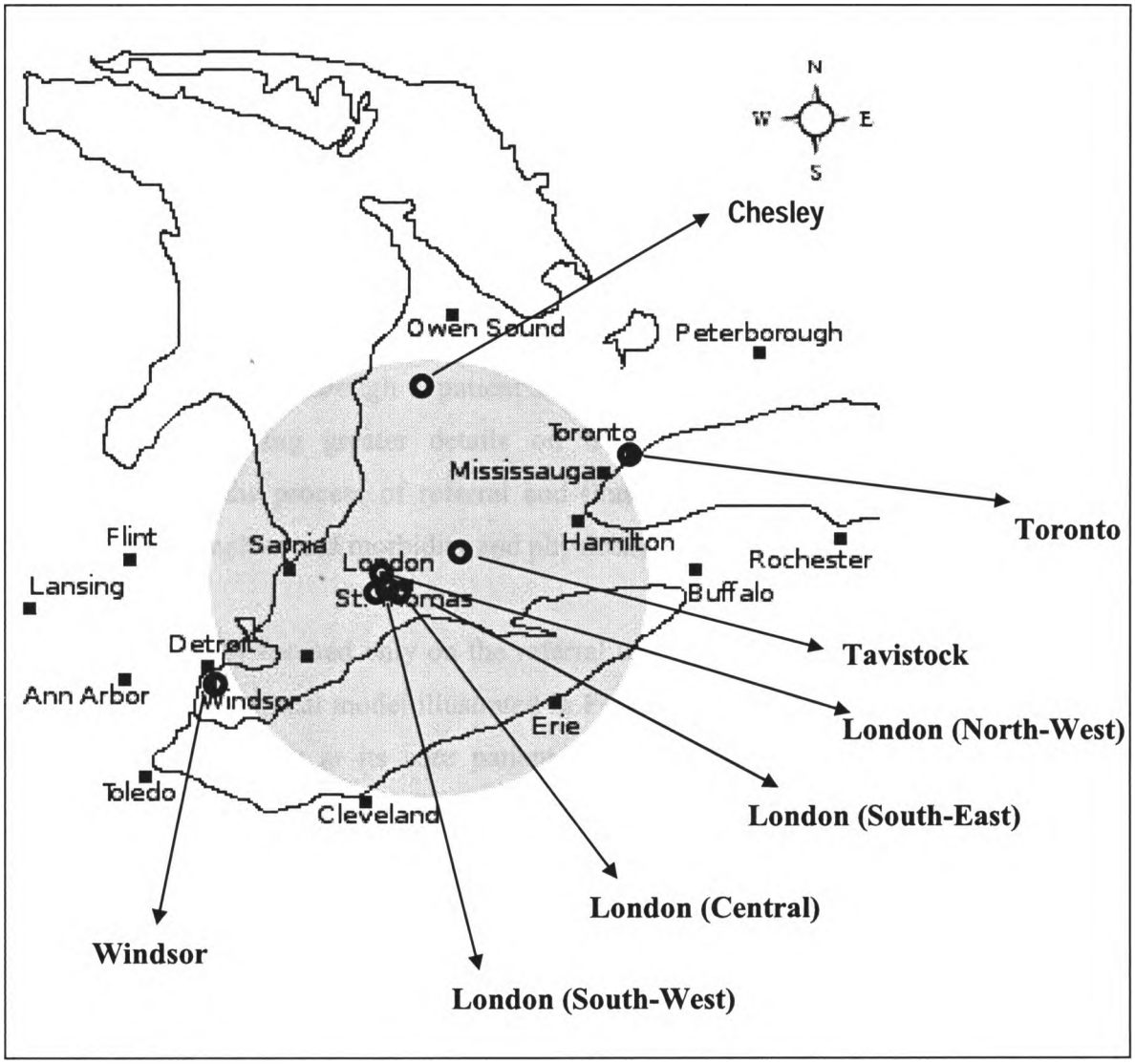

Figure 1: Family Practice Group Locations in Southwestern and Central Ontario, Canada

Conceptual Framework

Several frameworks have been proposed for analyzing the decision to refer and the referral process itself. Early literature by Shortell (35) suggested that the referral process involves two decisions: whether or not to refer, and who to refer to. They modeled these decisions as a function of patient, physician and community variables. Shortell and Vahovich (28) used a similar model in their study but placed practice and community related variables with the collection of physician variables. Chan et al (26) also modeled their analysis and discussion of referral rates against patient, physician, and community variables. The researchers suggested that these factors influence the decision to refer directly or indirectly through a patient's needs or demands. Reid (25) extended these models by including greater details on the patient's burden of morbidity. They conceptualized the process of referral and illustrated that each stage is influenced by patient demographics and morbidity and physician and system factors.

The present study focused only on the referral decision and did not consider the referral process. The conceptual model illustrated in **Figure 2** is based on previous literature (22, 25, 35) by indicating at its core patient and physician factors influencing specialist referral. Shortell (35) found patient illness and preference, as well as physician skill to be the most important variables. Furthermore, Cowen et al's (22) conceptual model indicated that a referral is a function of patient and physician characteristics. Therefore our model will be limited to the characteristics at the physician level and below. Practice and community level variables were considered in other studies and included specialist availability (21, 61), size of practice (21, 27, 28), and practice location (21, 61, 62). These factors were controlled for by the nature of the inclusion criteria of the original study. Eligible practices were limited to those with only 4-6 physicians and based in southwestern and central Ontario as outlined in **Table 2**.

Laboratory measurements are frequently used in studies that assess outcomes of patients in primary vs. secondary care (32) and describing the patient population attending DEC's.

Figure 2: Conceptual Framework for the Present Study

We have therefore built on the existing literature by including a cluster of visit level variables as having an impact on specialist referral. Reid (25) pioneered the use of disease related factors in impacting referral decisions, and we went a step further to suggest that physicians are influenced by the laboratory measurements and conditions present at a particular visit.

The visit level variables proposed include any examinations performed and tools used at the visit (lifestyle counseling or neuropathy examination), any laboratory measurements available at the visit (A1C, ACR, blood pressure etc.) and any outcomes that came as a result of the visit (diagnosis made).

Patient level variables included demographics (age, sex etc.), diagnoses and co morbidities (eye disease, heart problems etc.), health care utilization (number of visits during study period) and diabetes related variables (number of years with diabetes). Since our focus was on visit and patient level variables, physician level variables were not assessed in our analysis. Physician level variables that are typically included in the literature include gender, number of years in practice and the number of patients cared for. These variables are reflected in our conceptual model and were controlled for by including dummy variables in the final model.

Dataset for the present study

The original study resulted in the collection of multiple patient visits over a four and a half year time period. Any diabetes related referrals that occurred during that time period were also recorded. The unit of analysis for the present study was the patient-PCP encounter. A patient-PCP encounter is defined as any interaction between the physician's office and the patient that could have resulted in the decision to refer the patient for additional diabetes care. Therefore, an encounter also included phone calls. For the purposes of the present analysis, data was organized so that all information about a patient that a physician may use to assess the patient's need for specialist care was linked to the appropriate encounter. The assumptions made for this linkage are described. This

data organization resulted in a sample size of 9,443 visits by 396 patients. Treating the patient as the unit of analysis may have been easier to interpret and may have been useful in defining the population at high risk for referral, but would move the analysis away from the point of decision making. Assessing referrals at the level of the patient-PCP encounter was believed to offer more insight into the factors associated with a primary care referral.

The central component of a research question examining referrals is the context in which the decision takes place. In most, if not all cases, this is the patient-PCP encounter. For most patients, the initial entry into the health care system is with their family physician. This is where the majority of patients enter the system and gain access to the range of services that are available. Although there are some exceptions, such as the university setting, walk-in health clinics and emergency rooms, for most individuals and specifically for service use associated with chronic diseases, this framework is the most relevant.

Dependent variable

The primary outcome of our analysis was whether or not a referral took place following a patient-physician encounter. A referral was defined as a decision made by the family physician to consult a specialist for the care of their patient or to prompt the patient to seek care for services that allow for self-referral. The referral must have occurred during the study period – May 1, 1999 to November 1, 2003 and could have been to any medical specialist or non-medical specialty including diabetes educators and dietitians. A list of the medical specialists and non-medical specialties included in our study can be found in **Table 3**. The outcome is binary: 0 = No referral, 1 = One or more referrals.

In the original study, chart auditors were asked to record any note indicating that a referral had taken place. The intent was to see if the management of care had changed as a result of the implementation of the POC systems. Ideally, each referral that was made by the family physician would be recorded as such at a particular patient visit. However, this was not the case. Preliminary analyses revealed

Table 3: List of Medical Specialists and Non-Medical Specialties

Medical Specialist	Non-Medical Specialty
Diabetes Specialist	Dietician
Cardiologist	Diabetes Educator
EMG/Neurologist	Pedorthist
Nephrologist	Chiropodist
Ophthalmologist	Other Foot Specialty
Urologist	Optometrist
Internist	Other
Other	

that out of 439 referrals made, only 222 (50.6%) were actually associated with a patient-PCP visit. Further analysis revealed that 75% of the referrals were made within 13 days of a patient visit. This difference might be a result of the administrative processing delays that may take place in a busy family physician setting. For example, the physician may decide to refer a patient to a specialist the day of the patients visit or a couple days later by notifying the secretary of this intention. Based on our preliminary analysis and discussion with a diabetes specialist, a two week window or lag time was used to capture all referrals. This lag time was thought to account for delays in processing the referral and/or booking the appointment with the specialist. Any referral that took place within 14 days of a patient-PCP encounter was classified as a positive outcome. Beyond a two week window we were less confident of the relationship between a visit and a referral. The only exception to this rule was for optometrist referrals. Eye referrals were not captured in the chart audit data as they were for other specialties. Instead, we were provided with actual eye visits attended by the patients. In this case, to capture a referral stemming from a physician visit required the patient to attend an appointment with their optometrist. Furthermore, optometrist referrals are unique because a patient is able to self-refer to this specialty. Discussions with a diabetes specialist revealed that the PCP likely prompted the patient to see their optometrist. Because of these characteristics, a 90 day window was implemented to capture appropriate referrals. Extending the lag period beyond 14 days after the original patient-PCP visit accounted for a patient's possible delay in scheduling a visit with their optometrist and/or the wait times to see the specialist. Cowen et al (22) used a similar approach to capture referrals. A referral in their study was defined as a face to face encounter to a specialty physician within 90 days of the PCP encounter. Please refer to **Figure 3** for an illustration of these methods.

Independent variable selection and construction

Based on the conceptual framework, 44 variables were thought to be associated with the decision to refer. To further assess the likely contribution of each variable to the referral decision, a diabetes specialist was consulted. This discussion led to the elimination of five variables: 1. Diabetes discussed or flowchart used during the visit; 2. If the patient owns a

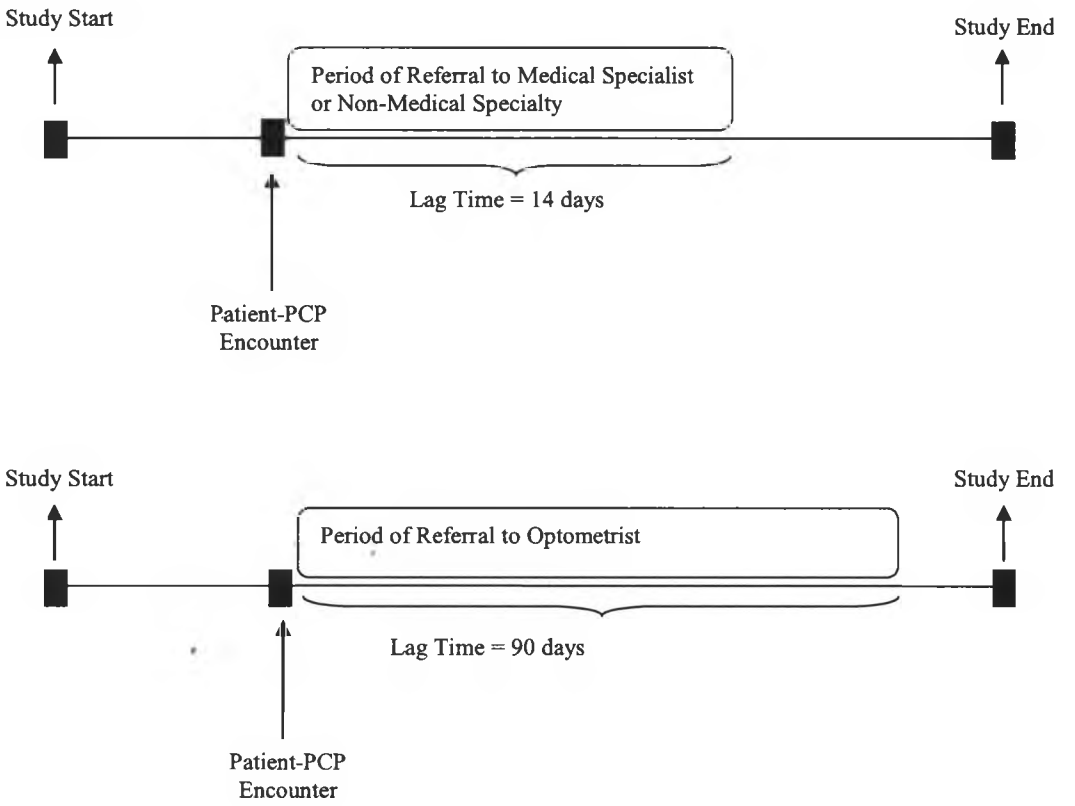

Figure 3: Definition of Referral.

glucose meter; 3. The number of minutes it takes the patient to get to the specialists office; 4. The number of hours the physician works per week; 5. The physicians level of interest in diabetes management. Reasons for variable omission included correlation with other variables, the reliability of self report measures and the variable being too distal from the actual referral decision. Variables were constructed based on a consideration of clinical decision cutoffs, and the distribution of the data. The focus of the present study is on visit and patient factors. Physician factors were not analyzed, but were controlled for in the analysis by using dummy variables for each physician.

Few published studies assess the effect of visit variables on referral decision making at a patient-PCP encounter. Details of a particular patient-PCP encounter are the most proximal factors to the physician's decision to refer. These factors were constructed to reflect the circumstances under which a clinical decision would be made. The final list of visit and patient factors included in the univariate and bivariate analyses are listed in **Table 4**.

Lifestyle counseling, neuropathy examination and whether a diagnosis was made at the visit were coded as binary (1=Yes, 0=No). Weight was left as continuous. All other laboratory measurements were coded as Normal, Elevated or Not Measured based on the 2008 CPG's (7). Elevated Blood Pressure (>130/80mm Hg), A1C (>7.0%), ACR (>2.8mg/mmol for female and >2.0mg/mmol for male), Triglycerides (>1.5mmol/L), TC:HDL Cholesterol (>4.0mmol/L) and LDL Cholesterol (>2.0mmol/L) are common clinical screening tools for the management of diabetes and its co morbidities.

Any lab value that had not been measured at a particular visit was coded as "Not Measured." In this case, the physician did not have any clinical test to base a referral decision on. Similar to the outcome variable, any laboratory measurement recorded 14 days before a patient visit or 14 days after a patient visit was associated with that particular visit. It was important to include 14 days after the index visit because a referral may have been suggested pending the results of a laboratory test. Additionally, it was believed that lab values recorded beyond 14 days would not be

Table 4: Variables Included in the Univariate and Bivariate Analyses

Visit Factors	Patient Factors
1. Examinations Performed and Tools Used at Visit Lifestyle Counseling Neuropathy Examination **2. Clinical and Laboratory Measurements Available at Visit** Blood Pressure Weight A1C ACR Triglycerides TC:HDL Cholesterol LDL Cholesterol **3. Visit Outcome** Diagnosis Made at Visit	**1. Demographics** Gender Age Occupation Education Drug Benefit Plan Residence Income Smoking Status **2. Diagnoses and Co morbidities** Eye Problems Skin Problems Neuropathy Nephropathy Stroke Lipid Problems Peripheral Vascular Disease Heart Problems Obesity Other Conditions Number of Co morbidities **3. Health Care Utilization** Prior Specialist Care Years with Family Physician Number of Visits during study period **4. Diabetes Related Variables** Glycemia Treatment Duration of Diabetes

given as much weight to a physician's clinical decision. Please refer to **Figure 4** for an illustration of this condition.

Patient variables are also listed in **Table 4.** These factors are not dependent on a particular patient-PCP encounter. They remain constant over the entire length of the study. Glycemia treatment was defined as either unknown, under no control, on an oral diabetic agent, or on insulin. This information was indirectly extracted from the patient concordance questionnaire. It was known if the patient was on insulin at baseline or during the study and if the patient had ever been prescribed diabetic pills. Therefore, it could be inferred that those patients who had been prescribed pills but were not on insulin must be on oral diabetic agents. If the patient did not respond to any of the questions related to glycemia treatment, their status could not be defined and was therefore classified as unknown. Prior specialist care was defined as if the patient had seen a specialist in the two years prior to the start of the study. A patient's occupation was defined as working, not working, retired or unknown. Education was collapsed into any post-secondary education, completed high school or less or unknown. These decisions were made after univariate analyses revealed very few observations in some categories. Income was based on the patient's postal code. Their six digit postal code was linked to the appropriate dissemination area and average individual income for that area was used as a proxy for patient income. This information was taken from the 2001 Canadian Census. Rabi et al (57) used the same approach to extract patient income. Income was left as a continuous variable. Patient place of residence was also determined from the patient's postal code. A postal code containing "0" was classified as rural, otherwise, it was urban. Income, occupation and education have each been found to explain socioeconomic status on their own; however, all three are often found in analyses because they offer different components an individual's socioeconomic status (63). Patients were classified as smokers, non-smokers, or status unknown. Those patients who were never smokers or former smokers were classified as non-smokers. The patient's most recent smoking status was used. Number of co morbid conditions, duration of diabetes, number of years with the family physician, number of family physician visits during the study

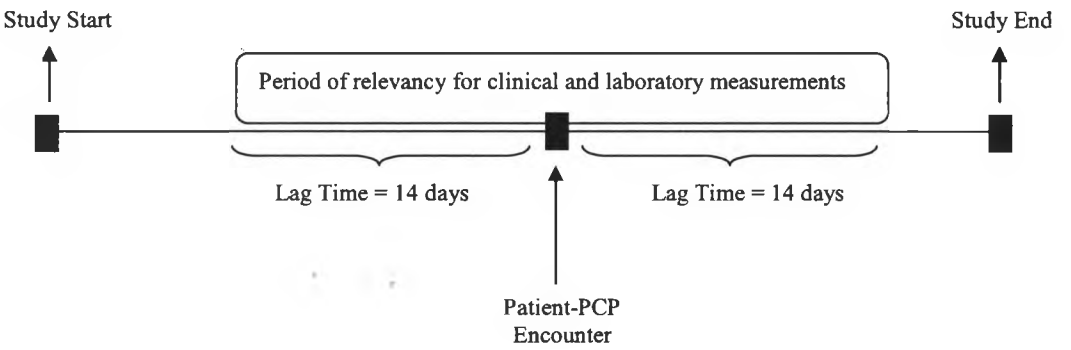

Figure 4: The Relationship between a Patient Visit and a Patient Clinical or Laboratory Measurement.

period, and the age of the patient were left as continuous variables. All ten disease categories (eye problems, skin problems, neuropathy, nephropathy, stroke, lipid problems, PVD, heart problems, obesity and other) indicate whether the patient has ever had one of those conditions. A composite score of the ten disease categories – number of co morbid conditions – demonstrated a patient's degree of ill health but does not necessarily depict the severity.

Missing data

Each patient visit was linked to most recent laboratory measurements, patient variables and a physician identification number. Laboratory measurements made beyond the 14 day window before and 14 day window after a visit were not included in the analysis. Therefore, not every visit will have a laboratory measurement linked to it. A1C, ACR, LDL, HDL, total cholesterol and blood pressure were not measured at every visit. An unavailable laboratory measure was not discounted as missing. It was instead placed in a "Not Available" category to reflect that the physician did not have access to any recent laboratory measurements. Missing patient categorical variables were coded as such to maintain all 9,443 patient-PCP encounters in the analysis. Patient age, income and number of years with the family physician had 2.02%, 3.54% and 12.37% missing cases respectively. The missing patient variables were handled by imputation of the mean. Missing cases were assigned an age of 67, income of $34,584 and as having been with their family physician for 13 years.

Data Analysis

The unit of analysis was the individual patient-PCP encounter. Univariate, bivariate and GEE analyses were performed using SPSS Version 16.0. The forward and backward stepwise logistic regression analyses and diagnostics were performed using STATA Version 10.

Univariate analyses were performed on the 34 variables, each at the appropriate visit or patient level. Based on the univariate analyses it was determined if the variables should

be coded as categorical or dichotomous. Bivariate analyses were used to look at the relationship of each variable with the outcome. This analysis was performed on the 9443 visits. Chi-square analyses were used in the analysis of categorical variables while t-test's for differences in means were used for continuous variables. This method of variable analysis is a valuable pre-selection tool. It allows for the elimination of insignificant variables and inclusion of significant ones (64).

All variables that were significant from the bivariate analysis at the 0.10 level were included in the multivariate analysis. We used generalized estimating equations (GEE) to determine the factors that influence referral. GEE is an extension of the generalized linear model (GLM) and is an appropriate method for analyzing clustered binary outcome data. It takes into account the correlation between outcome responses for the same subject. We controlled for multiple visits per patient by accounting for the clustering of observations within patients. The patient identification number was used as the repeated measures variable. Since we had a large number of clusters (396 patients) the estimates tend to be reliable even when the correlation structure is mispecified. The correlation structure is specified to explain how the response variable is related within each patient. An "exchangeable" structure was used for our analysis, meaning that within each patient, the outcome for each visit is equally correlated with every other visit. The ideal matrix would be one that is unstructured. This matrix would have SPSS estimate the correlation between each visit, however this method would not converge because the number of correlation parameters that it had to estimate. Furthermore, the parameter estimates are accurate no matter what matrix is chosen (65) especially with a large number of clusters, and a correctly specified mean model (logit link). The difference in a physician's tendency to refer was controlled for by setting up dummy variables for each physician.

In order to ensure the robustness of our model, we also performed forward (entry criteria $p < 0.200$) and backward (exit criteria $p < 0.200$) stepwise binary logistic regression. The clustering option was used to account for the correlation between outcomes for each patient, and dummy variables for each physician were forced into the model.

Regression Diagnostics

Regression diagnostics were performed to assess the fit of the forward and backward stepwise logistic regression model. Deviance residuals were plotted against the predicted probability of referral, the observation number and all independent variables. The pseudo R^2, Hosmer-Lemeshow goodness of fit (GOF) test, classification matrices, receiver operating characteristic (ROC) curves and information criteria tests for these models were also assessed.

Chapter 4
Results

Sample Population

There were 9,443 patient-physician encounters available for the present study. The visits included were those that fell between May 1, 1999 and November 1, 2003, were diabetes related and involved the patient and their family physician. These visits came from 396 patients, under the care of 34 physicians at 8 family practice sites in southwestern and central Ontario.

The patient population was 55.8% male, had a mean age of 66.5 years and had been living with type 2 diabetes for an average of 11.2 years. The majority of the population lived in an urban area (67.9%). The most common condition found in the population was heart disease with 60.3% of the population having been diagnosed. There was an average of 3.1 diagnosed conditions per patient and 25.5% of the population had seen a specialist in the 2 years prior to the start of the study period. The average number of diabetes related visits per patient per year during the four and a half years was 5.7. **Table 5** describes the sample patient population on all measured variables.

Collectively, the 396 patients had 9,443 diabetes related visits from which referrals were possible. Chart audit data revealed that lifestyle counseling was performed in 29.1% of the visits and a neuropathy examination was performed in 5.3% of the visits. From the visits that had a blood pressure reading available (62.7%), 83.1% were above target (> 130/80mmHg). When available, the mean weight recorded at the visits was 194.0lbs, A1C was elevated (>7.0%) 64.4% of the time and ACR was elevated (>2.8mg/mmol Female and >2.0mg/mmol Male) 45.3% of the time. A diagnosis was made at the visit 2.9% of the time. **Table 6** describes the sample visit population on all measured variables.

Table 5: Distribution of Patient Level Variables

Patient Level Variables	**Number of Cases (%) N=396**
1. Demographics	
Gender	
Male	221 (55.8%)
Female	168 (42.4%)
Missing	7 (1.8%)
Age [a]	
	Mean = 66.6 (SD 12.3)
Smoking Status	
Non-Smoker	285 (72.0%)
Smoker	46 (11.6%)
Missing	65 (16.4%)
Formal Education	
Completed High school or Less	243 (61.4%)
Any Post-Secondary	106 (26.8%)
Missing	47 (11.9%)
Occupation	
Working	135 (34.1%)
Not Working	18 (4.6%)
Retired	180 (45.5%)
Missing	63 (15.9%)
Drug Benefit Plan	
None	40 (10.1%)
Ontario Drug Benefit Plan	165 (41.7%)
Work Plan	115 (29.0%)
Missing	76 (19.2%)
Place of Residence	
Urban	269 (67.9%)
Rural	127 (32.1%)
Income [b]	
	Mean = 34,584 (SD 9756.1)
2. Diagnoses and Co morbidities	
Diagnosed with Eye Problems?	
No	331 (83.6%)
Yes	65 (16.4%)
Diagnosed with Skin Problems?	
No	374 (94.4%)
Yes	22 (5.6%)
Diagnosed with Neuropathy?	
No	332 (83.8%)
Yes	64 (16.2%)
Diagnosed with Nephropathy?	
No	347 (87.6%)

Yes	49 (12.4%)
Had a Stroke?	
No	379 (95.7%)
Yes	17 (4.3%)
Diagnosed with Lipid Problems?	
No	244 (61.6%)
Yes	152 (38.4%)
Diagnosed with PVD?	
No	362 (91.4%)
Yes	34 (8.6%)
Diagnosed with Heart Problems?	
No	157 (39.7%)
Yes	239 (60.4%)
Diagnosed with Obesity?	
No	251 (63.4%)
Yes	145 (36.6%)
Diagnosed with other Conditions?	
No	238 (60.1%)
Yes	158 (39.9%)
Total Number of Diagnoses or Conditions [c]	Mean = 3.1 (SD 3.0)
3. Health Care Utilization	
Number of Visits per year during the four and a half year study period [d]	Mean = 5.7 (SD 3.1)
Appointment with Specialist in the past 2 years?	
No	246 (62.1%)
Yes	101 (25.5%)
Missing	49 (12.4%)
Number of Years with Family Physician [e]	Mean = 12.7 (SD 7.7)
4. Diabetes Related Variables	
Number of Years with Diabetes [f]	Mean = 11.2 (SD 6.8)
Own a Glucose Meter?	
No	44 (11.1%)
Yes	284 (71.7%)
Missing	68 (17.2%)
Type of Glycemia Treatment	
None	39 (9.9%)
Oral Diabetic Agent	266 (67.2%)
Insulin	58 (14.7%)
Missing	33 (8.3%)

a. Continuous variable with 8 (2.0%) missing cases; Measured in years.
b. Continuous variable with 14 (3.5%) missing cases; Measured in 2001 Canadian dollars.
c. Continuous variable with no missing cases.
d. Continuous variable with no missing cases.
e. Continuous variable with 49 (12.4%) missing cases.
f. Continuous variable with 82 (20.7%) missing cases.

Table 6: Distribution of Visit Level Variables

Visit Level Variables	Number of Cases (%) N = 9443
1. Examinations Performed and Tools Used at Visit	
Lifestyle Counseling Performed	
No	6693 (70.9%)
Yes	2750 (29.1%)
Neuropathy Examination Performed	
No	8943 (94.7%)
Yes	500 (5.3%)
2. Laboratory Measurements Available at Visit	
Blood Pressure	
Normal	998 (10.6%)
Elevated (Systolic >130 or Diastolic >80)	4917 (52.1%)
Not Available	3528 (37.4%)
Patient Weight [a]	
	Mean = 194.0 (SD 40.0)
A1C Values	
Normal	396 (4.2%)
Elevated (>7%)	715 (7.6%)
Not Available	8332 (88.2%)
ACR Value	
Normal	270 (2.9%)
Elevated (>=2.0 for Male and >=2.8 for female)	224 (2.4%)
Not Available	8949 (94.8%)
Triglyceride Value	
Normal	344 (3.6%)
Elevated (>=1.5mmol/L)	909 (9.6%)
Not Available	8190 (86.7%)
TC:HDL Cholesterol Ratio	
Normal	443 (4.7%)
Elevated (>=4.0mmol/L)	717 (7.6%)
Not Available	8283 (87.7%)
LDL Cholesterol Value	
Normal	239 (2.5%)
Elevated (>=2.0mmol/L)	902 (9.6%)
Not Available	8302 (87.9%)
3. Visit Outcome	
Diagnosis made at visit	
No	9168 (97.1%)
Yes	275 (2.9%)

a. Continuous variable with 6976 (73.9%) missing cases; Measured in pounds.

There were 9,443 visits that could have resulted in a referral to a specialist. A referral occurred at 354 of these visits. The referral rate is defined as the number of visits that resulted in a referral per 100 visits that occurred during the four and a half year study period. Therefore, the referral rate was 3.7 referrals per 100 patient-PCP visits. Please refer to **Appendix B** for details regarding what specialists and specialties the patients were referred to.

Bivariate Analysis Results

From the bivariate analysis results, 23 variables were found to be associated with a referral at the 0.10 significance level. The odds ratios and 95% CI for each variable are shown in **Table 7**. There were no significant differences between the referred and non-referred groups for mean weight (193.8lbs and 199.4lbs respectively, $p = 0.171$), mean number of years with diabetes (11.9 years and 11.9 years respectively, $p = 0.968$), whether or not a diagnosis was made at the visit ($p = 0.234$), patient education ($p = 0.826$), occupation ($p = 0.140$), income ($p = 0.441$) or place of residence ($p = 0.585$) and diagnoses for skin problems ($p = 0.924$), neuropathy ($p = 0.957$), stroke ($p = 0.906$) or PVD ($p = 0.111$). However, the referred and non-referred groups did differ significantly on a number of visit and patient level variables. Lifestyle counseling was more likely to be performed in the referred group (44.4% vs. 28.5%, $p = 0.000$), as was a neuropathy examination (11.9% vs. 5.0%, $p = 0.000$). Blood pressure ($p = 0.097$), A1C ($p = 0.088$), ACR ($p = 0.000$), Triglycerides ($p = 0.000$), TC:HDL ($p = 0.002$) and LDL ($p = 0.001$) measurements were more likely to be available in the referred group compared to the non-referred group. The referred group was younger (65.9 years vs. 67.9 years, $p = 0.002$) consisted of more males (63.3% vs. 54.5%, $p = 0.004$), and were more likely to be on insulin (20.3% vs. 16.6%, $p = 0.074$). A greater percentage of patients with a provincial or work drug plan were found in the referred group ($p = 0.049$). The referred group had a greater percentage of eye problems ($p = 0.000$), nephropathy cases ($p = 0.005$), lipid problems ($p = 0.000$), heart problems ($p = 0.041$), obesity ($p = 0.027$) and other conditions ($p = 0.054$) and overall had more complications than the non-referred group

Table 7: Bivariate Analysis Results

Independent Variable	Dependent Variable: Referred (%) (N = 354)	Dependent Variable: Not Referred (%) (N = 9,089)	P-Value*	Odds Ratio (95% CI)
Visit Level Variables				
1. Examinations Performed and Tools Used at Visit				
Lifestyle Counseling Performed				
No	197 (55.7%)	6496 (71.5%)	*Reference Group*	
Yes	157 (44.4%)	2593 (28.5%)	0.001*	1.997 (1.611 – 2.474)
Neuropathy Examination Performed				
No	312 (88.1%)	8631 (95.0%)	*Reference Group*	
Yes	42 (11.9%)	458 (5.0%)	0.001*	2.537 (1.814 – 3.548)
2. Laboratory Measurements Available at Visit				
Blood Pressure				
Normal	40 (11.3%)	958 (10.5%)	*Reference Group*	
Elevated (>130/80mmHg)	201 (56.8%)	4716 (51.9%)	0.071*	1.218 (0.983 – 1.509)
Not Available	113 (31.9%)	3415 (37.6%)	0.031*	0.779 (0.621 – 0.978)
Patient Weight				
All (lbs)	Mean =193.8	Mean = 199.4	0.171	1.003 (0.999 – 1.008)
A1C Value				
Normal	17 (4.8%)	379 (4.2%)	*Reference Group*	
Elevated (>=7.0%)	37 (10.5%)	678 (7.5%)	0.038*	1.448 (1.021 – 2.053)
Not Available	300 (84.8%)	8032 (88.4%)	0.039*	0.731 (0.543 – 0.984)
ACR Value				
Normal	26 (7.3%)	244 (2.7%)	*Reference Group*	
Elevated (>2.8mg/mmol Female and >2.0mg/mmol Male)	19 (5.4%)	205 (2.3%)	0.001*	2.458 (1.517 – 3.982)
Not Available	309 (87.3%)	8640 (95.1%)	0.001*	0.357 (0.257 – 0.495)
Triglyceride Value				
Normal	21 (5.9%)	323 (3.6%)	*Reference Group*	
Elevated (>=1.5mmol/L)	52 (14.7%)	857 (9.4%)	0.001*	1.654 (1.222 – 2.238)
Not Available	281 (79.4%)	7909 (87.0%)	0.001*	0.574 (0.441 – 0.748)

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TC:HDL Cholesterol				
Normal	26 (7.3%)	417 (4.6%)	*Reference Group*	
Elevated (>=4.0mmol/L)	40 (11.3%)	677 (7.5%)	0.008*	1.583 (1.129 – 2.220)
Not Available	288 (81.4%)	7995 (88.0%)	0.001*	0.597 (0.454 – 0.786)
LDL Cholesterol				
Normal	17 (4.8%)	222 (2.4%)	*Reference Group*	
Elevated (>=2.0mmol/L)	45 (12.7%)	857 (9.4%)	0.040*	1.399 (1.015 – 1.927)
Not Available	292 (82.5%)	8010 (88.1%)	0.002*	0.634 (0.479 – 0.841)
Diagnosis Made at Visit				
No	340 (96.1%)	8828 (97.1%)	*Reference Group*	
Yes	14 (4.0%)	261 (2.9%)	0.237	1.393 (0.805 – 2.410)
Patient Level Variables				
1. Demographics				
Patient Gender				
Male	224 (63.3%)	4949 (54.5%)	*Reference Group*	
Female	121 (34.2%)	3884 (42.7%)	0.001*	0.696 (0.557 – 0.870)
Missing	9 (2.5%)	256 (2.8%)	0.795	0.900 (0.459 – 1.765)
Patient Age**				
All (Years)	Mean = 65.9	Mean = 67.9	0.002*	0.986 (0.978 – 0.995)
Patient Smoking Status				
Non-Smoker	276 (78.0%)	6606 (72.7%)	*Reference Group*	
Smoker	35 (9.9%)	1001 (11.0%)	0.506	0.887 (0.622 – 1.264)
Missing	43 (12.1%)	1482 (16.3%)	0.038*	0.710 (0.513 – 0.981)
Patient Education				
Any Post-Secondary	79 (22.3%)	2124 (23.4%)	*Reference Group*	
High School or Less	227 (64.1%)	5681 (62.5%)	0.537	1.072 (0.859 – 1.338)
Missing	48 (13.6%)	1284 (14.1%)	0.763	0.954 (0.699 – 1.300)
Patient Occupation				
Working	111 (31.4%)	2615 (28.8%)	*Reference Group*	
Not Working	30 (8.5%)	550 (6.1%)	0.064*	1.438 (0.979 – 2.110)
Retired	150 (42.4%)	4236 (46.6%)	0.118	0.842 (0.680 – 1.044)
Missing	63 (17.8%)	1688 (18.6%)	0.713	0.949 (0.719 – 1.253)

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Patient Drug Benefit Plan				
None	20 (5.7%)	820 (9.0%)	*Reference Group*	
Work Plan	97 (27.4%)	2268 (25.0%)	0.297	1.135 (0.894 – 1.441)
Ontario Drug Plan	166 (46.9%)	3896 (42.9%)	0.134	1.177 (0.951 – 1.456)
Missing	71 (20.1%)	2105 (23.2%)	0.174	0.832 (0.639 – 1.085)
Patient Place of Residence				
Rural	93 (26.3%)	2508 (27.6%)	*Reference Group*	
Urban	261 (73.7%)	6581 (72.4%)	0.585	1.070 (0.840 – 1.361)
Patient Income**				
All (2001 CDN Dollars)	Mean = 34118.8	Mean = 34513.1	0.440	1.000 (1.000 – 1.000)
2. Diagnoses and Co morbidities				
Has the Patient Been Diagnosed with Eye Problems?				
No	262 (74.0%)	7527 (82.8%)	*Reference Group*	
Yes	92 (26.0%)	1562 (17.2%)	0.001*	1.692 (1.326 – 2.159)
Has the Patient Been Diagnosed with Skin Problems?				
No	329 (92.9%)	8459 (93.1%)	*Reference Group*	
Yes	25 (7.1%)	630 (6.9%)	0.924	1.020 (0.674 – 1.544)
Has the Patient Been Diagnosed with Neuropathy?'				
No	281 (79.4%)	7204 (79.3%)	*Reference Group*	
Yes	73 (20.6%)	1885 (20.7%)	0.957	0.993 (0.764 – 1.291)
Has the Patient Been Diagnosed with Nephropathy?				
No	293 (82.8%)	7978 (87.8%)	*Reference Group*	
Yes	61 (17.2%)	1111 (12.2%)	0.005*	1.495 (1.127 – 1.984)
Has the Patient had a Stroke?				
No	339 (95.8%)	8692 (95.6%)	*Reference Group*	
Yes	15 (4.2%)	397 (4.4%)	0.906	0.969 (0.572 – 1.641)
Has the Patient Been Diagnosed with Lipid Problems?				
No	178 (50.3%)	5440 (59.9%)	*Reference Group*	
Yes	176 (49.7%)	3649 (40.2%)	0.001*	1.474 (1.192 – 1.823)

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Has the Patient Been Diagnosed with Peripheral Vascular Disease (PVD)?				
Yes	48 (13.6%)	987 (10.9%)	*Reference Group*	
No	306 (86.4%)	8102 (89.1%)	0.112	1.288 (0.943 – 1.758)
Has the Patient Been Diagnosed with Heart Problems?				
No	109 (30.8%)	3281 (36.1%)	*Reference Group*	
Yes	245 (69.2%)	5808 (63.9%)	0.042*	1.270 (1.009 – 1.598)
Has the Patient Been Diagnosed with Obesity?				
No	203 (57.3%)	5738 (63.1%)	*Reference Group*	
Yes	151 (42.7%)	3351 (36.9%)	0.027*	1.274 (1.027 – 1.579)
Has the Patient Been Diagnosed with other conditions?				
No	184 (52.0%)	5194 (57.2%)	*Reference Group*	
Yes	170 (48.0%)	3895 (42.9%)	0.054*	1.232 (0.996 – 1.524)
Number of Patient Co morbidities**				
All	Mean = 4.2	Mean = 3.4	0.001*	1.064 (1.034 – 1.094)
3. Health Care Utilization				
Number of Visits per patient per year during the four and a half year study period**				
All	Mean = 6.9	Mean = 7.4	0.022*	0.992 (0.985 – 0.999)
Appointment with Specialist in the past 2 years?				
No	179 (50.6%)	5604 (61.7%)	*Reference Group*	
Yes	129 (36.4%)	2228 (24.5%)	0.001*	1.766 (1.415 – 2.204)
Missing	46 (13.0%)	1257 (13.8%)	0.655	0.931 (0.679 – 1.276)
Number of Years with the Family Physician**				
All	Mean = 11.0	Mean = 12.5	0.001*	0.973 (0.957 – 0.988)
4. Diabetes Related Variables				
Number of Years with Diabetes**				
All	Mean = 11.9	Mean = 11.9	0.968	1.000 (0.984 – 1.017)

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Type of Glycemia Treatment				
None	18 (5.1%)	733 (8.1%)	*Reference Group*	
Oral Diabetic Agent	230 (65.0%)	6034 (66.4%)	0.580	0.939 (0.752 – 1.173)
Insulin	72 (20.3%)	1508 (16.6%)	0.064*	1.284 (0.985 – 1.672)
Missing	34 (9.6%)	814 (9.0%)	0.675	1.080 (0.753 – 1.549)

* Significant at the 0.10 level.

**Continuous Variable

Note: Variables selected for the multivariate analysis were based on the t test statistic for continuous variables and the χ^2 test statistic for categorical variables.

(mean of 4.2 vs. mean of 3.4, p = 0.000). Furthermore, the patient's health care utilization history varied significantly between the two groups. The referred group had fewer number of visits per year with the family physician during the four and a half year study period (mean of 6.9 vs. mean of 7.4, p = 0.022); a greater percentage of the patients had a referral to a specialist in the two years prior to the start of the study (p = 0.000); and had been under the care of their family physician for a shorter period of time (mean of 11.0 vs. mean of 12.5, p = 0.000).

Multivariate Analysis Results

Table 8 describes the variables associated with referral from the GEE analysis. Unmeasured ACR was significantly associated with a referral. If there was no ACR measurement available at a visit the odds of a referral to a physician were approximately half (OR = 0.505, p=0.002) compared to when a normal ACR reading was available. If lifestyle counseling was performed during the visit the odds of specialist referral were greater by about one and a half times (OR = 1.526, p=0.002). Similarly, when a neuropathy examination was performed the odds of referral was greater than if the examination was not performed (OR = 1.663, p=0.018). The odds of a female being referred were half that of a males (OR = 0.574, p=0.000). Those patients having been with their physician for a greater number of years had a lower odds of referral (OR = 0.975, p=0.014) while those patients with a specialist appointment in the past two years had a greater odds of referral (OR = 1.486, p=0.008).

Stepwise logistic regression analyses were also performed. Please refer to **Appendix C and D** for the forward and backward regression models. The results were identical except that unmeasured triglyceride levels became significant in the stepwise regression procedure. Similar to unmeasured ACR levels, if triglycerides were not available during the visit, the odds of referral were lower than if they were measured and found to be normal or elevated (OR = 0.590, p=0.013).

Table 8: Multivariate Analysis Results

Variable	Number of Cases	Odds Ratio	95% Confidence Interval	P-value
Visit Factors				
1. Examinations Performed and Tools Used at Visit				
Performed Lifestyle Counseling				
No	6693		*Reference Group*	
Yes	2750	1.526	1.170 – 1.991	0.002*
Performed Neuropathy Examination				
No	8943		*Reference Group*	
Yes	500	1.663	1.089 – 2.539	0.018*
2. Laboratory Measurements Available at Visit				
Blood Pressure				
Normal	998		*Reference Group*	
Elevated (>130/80mmHg)	4917	1.031	0.721 – 1.477	0.866
Not Available	3528	0.992	0.675 – 1.457	0.966
A1C Value				
Normal	396		*Reference Group*	
Elevated (>=7.0%)	715	1.263	0.698 – 2.286	0.440
Not Available	8332	1.056	0.625 – 1.783	0.839
ACR Value				
Normal	270		*Reference Group*	
Elevated (>2.8 mg/mmol Female, >2.0 mg/mmol Male)	224	0.880	0.460 – 1.682	0.699
Not Available	8949	0.505	0.326 – 0.782	0.002*
Triglyceride Levels				
Normal (<1.5mmol/L)	344		*Reference Group*	
Elevated (>=1.5mmol/L)	909	0.911	0.499 – 1.660	0.760
Not Available	8190	0.568	0.258 – 1.246	0.158
TC:HDL Cholesterol				
Normal (<4.0mmol/L)	443		*Reference Group*	
Elevated (>=4.0mmol/L)	717	0.900	0.489 – 1.656	0.734
Not Available	8283	1.051	0.440 – 2.508	0.911
LDL Cholesterol				
Normal (<2.0mmol/L)	239		*Reference Group*	
Elevated (>=2.0mmol/L)	902	0.667	0.345 – 1.290	0.229
Not Measured	8302	0.822	0.387 – 1.744	0.609

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Patient Factors				
1. Demographics				
Patient Gender				
Male	5173		*Reference Group*	
Female	4005	0.574	0.445 – 0.741	0.001*
Missing	265	0.977	0.280 – 3.410	0.971
Patient Age**	9443	0.992	0.981 – 1.003	0.160
Smoking Status				
Non Smoker	6882		*Reference Group*	
Smoker	1036	0.920	0.640 – 1.324	0.655
Missing	1525	0.977	0.674 – 1.416	0.902
Patient's Drug Benefit Plan				
No Plan	840		*Reference Group*	
Ontario Drug Benefit Plan	4062	1.538	0.878 – 2.694	0.132
Work Plan	2365	1.579	0.872 – 2.860	0.132
Missing	2176	1.358	0.743 – 2.481	0.320
2. Diagnoses and Co morbidities				
Patient Diagnosed with Eye Problems?				
No	7789		*Reference Group*	
Yes	1654	1.250	0.865 – 1.807	0.234
Patient Diagnosed with Nephropathy?				
No	7485		*Reference Group*	
Yes	1958	1.074	0.768 – 1.502	0.676
Patient Diagnosed with Lipid Problems?				
No	5618		*Reference Group*	
Yes	3825	1.048	0.803 – 1.368	0.730
Patient Diagnosed with Heart Problems?				
No	3390		*Reference Group*	
Yes	6053	0.927	0.686 – 1.253	0.623
Patient Diagnosed with Obesity?				
No	5941		*Reference Group*	
Yes	3502	1.186	0.912 – 1.541	0.204
Patient Diagnosed with Any Other Conditions?				
No	5378		*Reference Group*	
Yes	4065	0.817	0.602 – 1.110	0.196
Total Number of Conditions Diagnosed**	9443	0.998	0.933 – 1.068	0.962
3. Health Care Utilization				
Number of Visits with the Family Physician Per Year During the Four and a Half Year Study Period**	9443	1.004	0.993 – 1.015	0.482

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Specialist Appointment in the Past 2 Years?				
No	5783		*Reference Group*	
Yes	2357	1.486	1.110 – 1.991	0.008*
Missing	1303	1.060	0.593 – 1.895	0.844
Number of Years with Family Physician**	9443	0.975	0.955 – 0.995	0.014*
4. Diabetes Related Variables				
Type of Glycemia Treatment				
No Control	751		*Reference Group*	
Oral Diabetic Agent	6264	1.061	0.696 – 1.617	0.784
Insulin	1580	1.172	0.715 – 1.921	0.530
Missing	848	1.358	0.743 – 2.481	0.320

* Significant at the 0.05 level

**Continuous Variable

Model Controls for physician ID, blood pressure, patient age, number of years with the family physician, A1C, ACR, Triglycerides, TC:HDL, LDL, patient gender, specialist appointment in the previous two years, drug benefit plan, type of glycemia treatment, smoking status, lifestyle counseling performed, neuropathy examination performed, eye disease diagnosis, nephropathy diagnosis, lipid problems, heart problems, obesity, diagnosed with another condition, total number of diagnoses, number of visits with the family physician during the study period.

Regression Diagnostics Results

Diagnostic tests were performed for both the forward and backward stepwise regression model. Both models produced near identical results. The Hosmer Lemenshow GOF test indicates a well-fitted model; while the positive predictive value of 7.08% indicates a poor predictive model. This result is likely due to the fact that the outcome is rare. Please refer to **Appendix E** for regression diagnostics results.

Chapter 5
Discussion

The present study determined the specialist referral rate (the number of referrals per 100 patient-PCP visits) for a population of patients with type 2 diabetes from select family physician practices in southwestern and central Ontario. The factors associated with these diabetes related referrals were also found.

In interpreting the referral literature and comparing results, it is important that differences between health systems, populations, methods used and included variables in each study are considered. Canada's health care system differs from the systems in the US, UK and others, patient populations can include all patients with diabetes, only newly diagnosed cases and other variations, the unit of analysis could be the patient, physician or health system, and each study differs in the variables included in the final model.

Canada's health care system operates under a gatekeeper model to specialist care. In order for patients to have access to specialist services, such as internists, cardiologists or ophthalmologists, the patients' family physician must refer them to a specialist. Since much of the referral literature has been generated from the US and the UK, care should be taken in generalizing these results to the Canadian context. Each country differs in the management and provision of health care resources. Donker et al (51) in 2004 compared the variation in referral percentages among five European countries and concluded that the relative ease of referral decision making and the extent of open access to medical care will influence referral practices. Additionally, a study in the US and the UK compared referral rates between the two countries. It was found that the US had much higher referral rates and this was likely due to specialist supply (27).

The patient population in each study was also quite variable and may have led to different results. Populations of patients with diabetes have a greater burden of morbidity compared to the general patient population and may have higher referral rates and different determinants of referral. Furthermore, the type of diabetes the patient has

(whether type 1, type 2, a mix of both, or newly-diagnosed), will have different characteristics and disease conditions making comparisons between studies difficult.

The development of methods to assess referrals has been described, and it has also been noted that the ideal level to analyze referrals is at the patient-physician encounter (22, 39). The present study was designed to assess referral decision making at each patient-PCP visit, as were several other studies (21, 22, 27, 35, 43, 46, 50, 66). Other research analyzes referrals at the patient level, physician level and even country level. In addition to various units of analysis, there are also variations in the definition of a referral, the number of practices, physicians, patients and visits involved in a study, data collection methods, research questions and types of specialists being referred to. These differences again highlight the need to compare and interpret findings with caution.

Sample Population

Our sample population consisted only of those patients with type 2 diabetes in southwestern and central Ontario. Specifically, our population was 55.8% male, had a median age of 69.92 years and a mean income of $34,584. This population is not representative of the entire population of Ontario which was 48.77% male (70), had a median age of 39.0 years (70) and a mean income of $34,498 (71) in 2006. Therefore, our study is not representative of the entire population of Ontario. It should be noted however, that our population is restricted to patients with type 2 diabetes. Type 2 diabetes is typically diagnosed at an older age and may therefore explain why the median age in our sample was much greater than the general population in Ontario.

Referral Rate

The present study revealed a referral rate of 3.7 referrals per 100 patient-PCP visits. This was derived from the referrals made during the 9,443 visits recorded over a four and a half year time period. Most referral research is limited to shorter study time periods. A consecutive 15 day window is commonly used to assess referral decision making. A 5.2%

(21), 5.1% (27) and 1.0%-7.0% (22) referral rate per visit has been found using the 15-day timeframe, while a one-week assessment of referrals revealed a 4% (50) referral rate per visit. Forrest et al (21, 27) had a very large general patient population, considered referrals to all specialties and collected data to specifically assess specialist referral. Cowen et al (22), assessed referrals only to five specialties, and included referrals only if the patient consulted the specialist within 90 days of the PCP visit. Franks et al (43) while assessing the sociodemographic factors that might determine differential referrals by primary care physicians found a 4.5% referral rate per visit over an approximate five year time period. No referral rate for a population of patients with type 2 diabetes was available for comparison.

Catherine A O'Donnell's (44) literature review assessed the variation in family physicians referral rates. It was found that physicians and practices differ greatly in their rates of referral. Shortell and Vahovich (28) also found that there are differences in referral rates depending on the specialty being referred to. Irrespective of the limitations in making comparisons between studies, the referral rate found in our study is within the range or slightly lower then what has been reported in the literature.

The referral rate in the present study and the comparison studies reveals the number of referrals made divided by the number of visits recorded during a given period of time. It is a relatively crude measure of the frequency of referral, provided that the number of patients, their characteristics, and the types of physicians involved are not considered. However, it does indicate the level of use of specialist services and allows comparisons to be made between populations.

A high referral rate indicates that at a given visit in a particular population, a patient is more likely to receive a referral. A lower referral rate indicates that the population has a lower chance of being referred at a given visit. The conditions or concerns presented at the visit are more likely to be managed by their family physician. The present study had a referral rate of 3.7 referrals per 100 patient-PCP visits. This rate is slightly lower than others reported, but only includes diabetes related referrals. The referral rate may in fact

be higher for this population if we were to consider referrals for other reasons; for example, surgery or psychiatry.

The limitations of the present study should also be considered when interpreting the referral rate and making comparisons to the literature. The accuracy of our referral rate may have been compromised by several factors. If a note was not sent back to the referring physician following a specialist visit and no note was made in the chart at the time the referral was made, the referral was likely not captured. Furthermore, no consideration was given to the use of specialist services through self-referral or referral between specialists. Therefore, extending the referral rate to interpret specialist service use may greatly underestimate resource requirements.

Determinants of Referral

The analysis revealed six variables that are significantly associated with a referral from a family physician to a specialist. This study benefits strongly from the availability of variables at the visit level. A referral is possible at each patient-PCP encounter, yet most literature does not assess the variables that change between patient visits.

If the ACR is not available at a particular visit, it was found that a referral is less likely to occur. The ACR is used to assess the presence of the protein, albumin, in the urine. This test is appropriate for assessing the presence of CKD and is also a predictor of cardiovascular disease. If an ACR measurement is present, the physician has more information to assess whether a referral to a nephrologist, cardiologist or other specialist should occur. Therefore, it seems logical that not having the ACR measurement would lead a physician to either assume that the kidney is functioning properly or to order an ACR laboratory measurement following the visit. To date, ACR has not been assessed as a predictor of referral.

If the physician performed lifestyle counseling during the visit, the patient is more likely to be referred to a specialist. It is probable that if a physician is discussing any aspect of a

patient's lifestyle such as diet, exercise and smoking cessation then the patient is in need of specialist advice (i.e. Dietitian or Diabetes Educator). Therefore, this increased tendency of referral when lifestyle counseling is present likely represents the decision to refer to a Dietitian or DEC. To date, the lifestyle counseling during a patient-PCP encounter has not been assessed as a predictor of referral. Similarly, if the physician screened for neuropathy during the visit, the patient is more likely to be referred to a specialist for diagnoses and/or treatment. This seems logical because if screening takes place, there is more chance of having a problem identified, and therefore a greater likelihood that the physician will refer.

The analysis also revealed that male patient visits were more likely to result in a referral compared to female patient visits. This result is consistent with much of what has been found in the literature (21, 43, 45, 46, 49). However, some studies have found the opposite (24, 52, 61). Differences in the types of populations analyzed, the data collection methods used and the variables included in the final model could explain the discrepancy between results. Despite these differences, it seems plausible that males have an increased tendency to be referred. For example, in cardiovascular disease, it has been found that female patients are often under diagnosed and undertreated (67). This finding may also be applicable to diabetes management and care.

The fewer the number of years the patient has been with the family physician, the greater the chance of referral. This finding may be a result of the physicians comfort level in dealing with his or her patients. A physician may feel more comfortable treating patients for which a history is known. Furthermore, if the physician receives a new and complicated case, he or she is more likely to refer to an internist or other diabetes specialist right away for some advice. To date, the number of years with a family physician has not been assessed as a predictor of referral.

Finally, if the patient had an appointment with a specialist in the past two years, they are more likely to be referred to a specialist. This finding is supported by the relationships that are established between a patient and the specialist. Patients who have been referred before are likely to have made a connection with a specialist that will continue in the

future. Diabetes care advocates annual checkups so it is likely that the patient will be re-referred to the specialist at designated intervals. Greater specialist use may also indicate a more complicated patient. The literature also identified that the number of previous referrals is a positive predictor of future referrals (49, 68).

Interestingly, A1C and duration of diabetes were not associated with referral to specialist care. A1C is a commonly measured variable in practice but does not appear to have an influence on referral decision making in our population. A1C and duration of diabetes have been found to be significant in a previous case-matched study of who is referred for diabetes care (69). It was found that referred patients are more likely to have a higher A1C and a longer duration of diabetes.

Several additional factors have been put forth as predictors of referral from family physician to specialist care. Research that used the visit as the unit of analysis also found longer visits (43), higher blood pressures (68), Caucasian patients (46), fewer medications (43), fewer diagnoses (43) and insured patients (21) having a greater likelihood of referral. If a diagnosis was made at the visit there was also a greater chance of referral (43). Although these findings were not found in our study, they were based on populations from the US and not limited to patients with type 2 diabetes. Patient age and health insurance plan were other significant variables, but produced inconsistent results in the literature. Forrest et al (21) found that the likelihood of referral increases for patients over the age of 65, while Chen et al (46) found the opposite. Franks et al (43) found that having Medicare increases the chance of referral, while Forrest et al (21) found the opposite. Referral literature that uses the patient as the unit of analysis reveals even more discrepancies between significant variables. Increasing patient age is found to be a predictor of referral in some studies (24, 26, 45, 52, 56) while decreasing patient age is found to be a predictor in others (32, 58). Furthermore, poorer health status increases the chances of referral in one study (32) but decreases chances of referral in another (37). Other variables found to be associated with a greater chance of referral include higher income (26, 37), more education (37), suboptimal control of diabetes (58), urban residence (32, 52), and being on insulin (54). Literature that assessed physician referrals

for specific populations (hematuria patients and hypertensive patients) found a greater number of family physician visits (49, 68) and higher blood pressure (68) to be associated with a greater tendency of referral.

The introduction of visit level factors in our study may have had an impact on the presence of other factors that were previously found to be associated with referral. For example, including laboratory measurements such as A1C, ACR and cholesterol may have picked up the variation contributed previously by patient morbidity and health status. Furthermore, the patient population is limited to those with type 2 diabetes, in southwestern and central Ontario and considers only referrals for diabetes related care. These factors may change the context of decision making for family physicians during a patient encounter.

Limitations

The present study was particularly limited by the dataset used for analysis. As a secondary dataset, it was originally designed to assess changes in diabetes care and management after the implementation of POC machines. Referrals were not associated with a specific visit, but instead recorded separately. Therefore, the assumptions that were made to most accurately assess factors associated with a referral may not be entirely accurate if referrals were not connected with a specific visit correctly. Additionally, variables such as patient race, health status and medications were not available for the regression analysis. These variables have been found to be significantly associated with referral in other studies so they may have changed our results if they were available. Mean individual income from 2001 was used as a proxy for patient income based on the patients postal code. This variable may not accurately reflect the patient's true income.

Data collection consisted of a detailed chart audit and patient questionnaires which present the possibility for biased results. The chart audit data in particular may suffer from ascertainment bias. Our sample population consisted of all visits that were recorded in patient charts. Some patients may have contributed more visits than others.

Furthermore, a greater number of patient visits would have resulted in a greater number of laboratory measurements available for that patient. It may be possible that the patient visits and laboratory measurements that were available from the charts are a reflection of the most ill patients because they were likely to be the more frequent users of physician care.

Variables such as type of glycemia treatment, health insurance plan, employment, education, and previous specialist visits were some of the variables obtained through the patient questionnaire. This method of data collection is subject to recall bias. If present, this may have also impacted our results. Finally, we do not have detailed information on the duration and reasons for previous specialist care, or plans for follow-up, which would influence whether or not a referral were to occur.

There were 23 variables found to be associated with referral from the bivariate analysis, with a limited sample size to perform a multivariate analysis. The ideal method for this type of study would be to perform a multilevel analysis and assess the variance at each level: visit, patient and physician. However, due to the large number of variables and a relatively rare outcome, this was not possible.

Implications of Findings and Future Directions

The referral rate findings suggest that referrals from patient-PCP visits are quite common in our population. The variation in variables found to be associated with referral also suggests that patients may be referred for different reasons compared to type 1 or newly diagnosed patients. Therefore, future research should assess referral patterns for patients with type 2 diabetes separately from other populations. This is especially important when considering resource allocation, planning and policy and guideline development for physician referral practices. Specialist care has also been found to be associated with better patient outcomes than PCP care alone (32). This is further support for addressing the use of specialist services in the management of a patient's diabetes.

The literature and the present study also indicate that there are complications in assessing referral practices. Most data collection is not purposively targeted to assessing referrals so research typically relies on secondary data. Some studies have been based on claims data while others use patient or physician databases. Studies using primary data collection methods have been done, but are typically limited to shorter time-frames (21, 27, 50). These findings suggest that small changes in administrative policies at the family practice level may offer significant advantages for future referral research. For example, the development of a system for the physicians to keep a record of what referrals are made, at what visit, if the patient actually saw the specialist and the outcome of the visit, all within the patients chart would greatly aid referral research. Future research should target the development of a simple administrative system to record and track referrals from the initial visit at which they were made. The adoption of electronic health records may facilitate this change. Referral studies could then piggyback on other research collected from chart audit data if referral information was included.

The factors found to be associated with referral were surprisingly not indicative of a patient that has a higher burden of morbidity. Three visit factors were associated with referral: unmeasured ACR and performance of lifestyle counseling and neuropathy testing at the visit. This indicates that the characteristics of the visit itself have an important influence on the variation in referral decision making. Although it is difficult to assess the appropriateness of a referral without a comprehensive view of the visit, it appears from the results that referrals are not dictated by conventionally accepted factors such as A1C value, blood pressure, the presence of specific diseases, the number of conditions or co morbidities and the patient's duration of diabetes. Visit level factors should be assessed in future investigations. Common laboratory measurements available at family physician visits for patients with type 2 diabetes include A1C, ACR, blood pressure, total cholesterol, LDL, HDL, triglycerides and BMI. Although many were not significant in our study, research in other populations may reveal different results. Other visit level variables of interest for future research may include a comprehensive measure of the burden of morbidity cared for during the visit, if a new problem is presented at the visit, how certain the physician is of a diagnosis and the length of the visit. These visit level

variables in particular may be useful for when practices or other interested parties are assessing the variations in referrals between practice sites and physicians or assessing the determinants of referral for a specific population.

Our results also demonstrate that male gender, fewer numbers of years with the family physician and previous referral are indicative of future referral. The finding that specialist referral is dependent on past referral suggests that it may be important for family physicians to continually re-evaluate the need for specialist advice in the care of their patients, and it also presents an opportunity for future research. Our finding that previous specialist referral increases the likelihood of future referral is likely widely variable between countries, communities and even physicians. In Ontario, shared care models have been implemented in order to meet the demands of chronic conditions. These models allow specialists and specialties to team up to offer comprehensive care to their patients. For example, patients with type 2 diabetes being managed by a team of health care providers may be offered services from a dietitian, diabetes specialist and lifestyle counselor, among others, in one convenient location.

The presence of shared care will influence the relationships between physicians and medical specialists and non-medical specialties. In practices where these relationships do exist, the communication between physicians may be high, and may subsequently increase the satisfaction of the relationship leading to more referrals in the future. Where these models do not exist, the communication between physicians may be more limited. This may create dissatisfaction with the specialist being referred to and prevent future referrals. Some patients may even be referred simply because they have been referred in the past, not on the basis of need. Beyond the level of satisfaction with the specialist being referred to, the logistics of these shared care models may vary between physicians and between specialties being referred to. For example, some physicians may refer once and then leave any subsequent follow up visits to the discretion of the patient and specialist. In other cases the physician may be involved in initiating every visit between the patient and the specialist. With this in mind, there may be differences between the

factors associated with referral depending on whether it is the first, second or third referral to a specialist and depending on what specialist is being referred to.

Future research should assess the determinants of referral separately for patients who are being referred for the first time and for those who have had multiple referrals. Furthermore, with a large enough sample population, the factors associated with referral should be assessed separately for each specialist being referred to. For example, our study is dominated by ophthalmologist referrals so these referrals may in fact be driving the results of our study. An assessment of referrals separately depending on the specialist being referred to may reveal some interesting results.

Other patient level variables that should be assessed in future research include age, socioeconomic status, race, duration of diabetes, place of residence, relationship with the family physician and number and doses of medications.

Our research did not directly assess the influence of physician factors on specialist referral. We were interested in the visit and patient factors associated with referral and therefore controlled for the variation in referral practices between physicians by using dummy variables. Physician factors, however, have been found to be important determinants of referral. Physician gender, age, number of years in practice, number of patients being cared for and level of morbidity of the patient population should be assessed in future research. Additionally, research should assess the comfort level of physicians in treating patients with type 2 diabetes and assess their comfort in treating new patients compared to patients who have been with them for a longer time. Possible research techniques could include physician focus groups and/or case studies of patients with varying characteristics and conditions. These findings may indicate an area that can be targeted for improvement and result in more appropriate use of specialist services.

The visit, patient and physician factors mentioned above have been found to be important determinants of referral in our study and throughout the literature. Our study builds on existing literature by assessing patients with type 2 diabetes separately from patients with

type 1 diabetes, using the patient-PCP encounter as the unit of analysis and introducing the importance of visit level variables in specialist referral research. Future research should build on this study by obtaining a larger sample population with a larger number of outcomes, collecting the suggested visit, patient and physician level factors, obtaining accurate measures of specialist supply and using multilevel statistical methods to tease out the contribution of each level of factors on the decision to refer. Understanding the basis for physician referral decision making is important to ensure that unnecessary referrals are avoided while referrals for patients in greatest need are encouraged.

The large amount of unmeasured laboratory tests and lack of lifestyle and neuropathy tests should not be interpreted as a failure to perform the necessary tests recommended by the CPG's. For most measurements, it is recommended that they are taken immediately after diagnosis and every year thereafter. Some patients may have satisfactory measurements and therefore have lab tests less often. Furthermore, some patients may have these measurements taken by other physicians or specialists.

Finally, the inclusion of an expanded discussion and set of referral guidelines in the CDA's CPG's could be considered. This addition may help to define the roles and responsibilities of family physicians and specialists, make referral criteria publicly available to all health care professionals, and help prevent unnecessary referrals and subsequent consumption of limited health care resources.

Conclusions

The results of the present study can be used to focus efforts on maximizing the number of visits that appropriately result in a referral to specialist care. Results indicate that patients in our population are not being referred based on severity of disease, but instead on factors such as gender, physicians comfort level, and previous specialist care.

The design of new research to assess reasons for referral should focus on the details of what was discussed and recommended at the specific patient-PCP encounter. The yes or

no decision of the family physician to refer the patient to specialist care should be recorded in the notes of each visit. Furthermore, it may be of value to assess the comfort level of the referring physicians in managing each type of patient.

CPG's for the care of patients with type 2 diabetes may benefit from the inclusion of more specific guidelines for under what circumstances it is appropriate to refer. The family physician should also be cognitive of each patients current specialist care use and continually review the necessity of this care.

Health care resources are limited. An assessment of reasons for physician's use of specialty care is an important stepping stone in evaluating the appropriateness of referrals and subsequent health care resource use.

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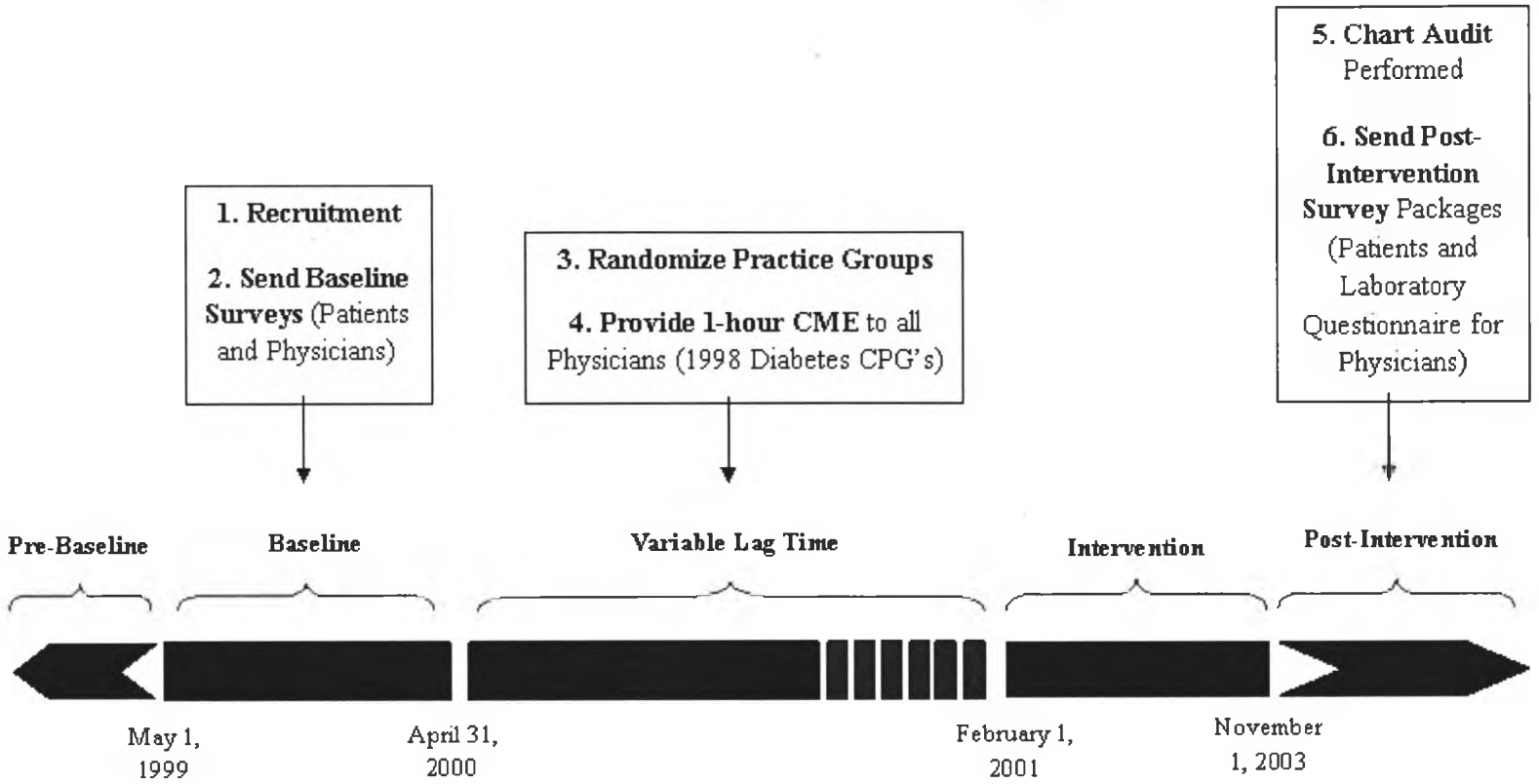
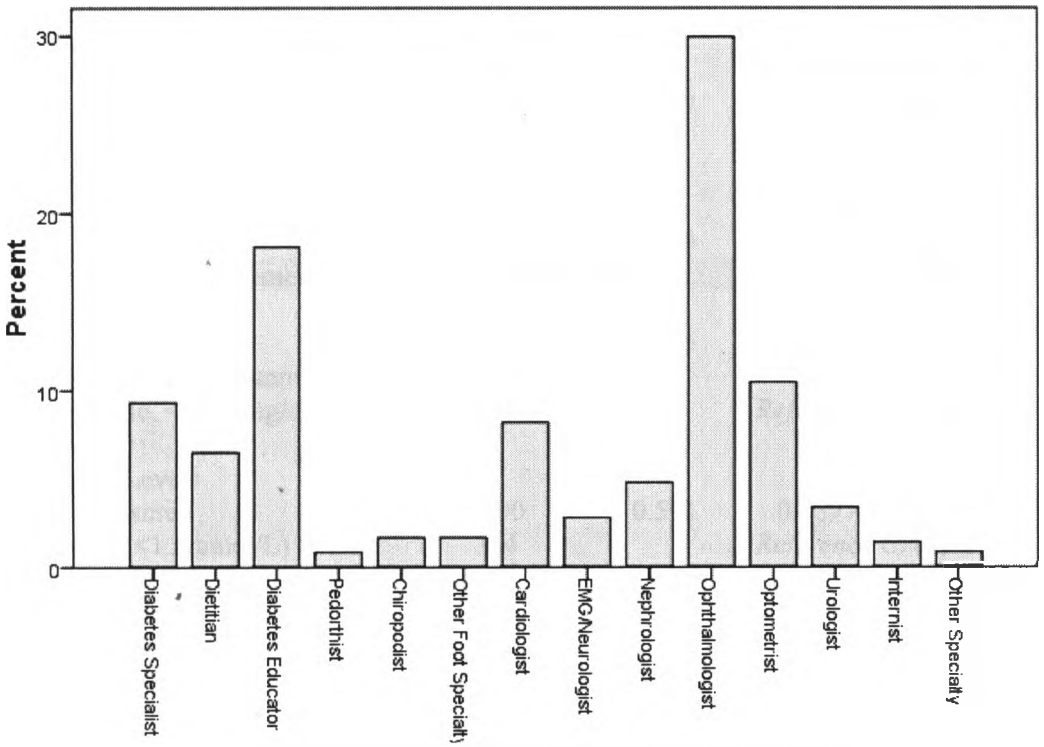
Appendix A: Original Study Timeline



Appendix B: Breakdown of Specialist Referral -
Who patients are referred to

Breakdown of Specialist Referral



Medical Specialist or Non-Medical Specialty

Appendix C: Forward Stepwise Logistic Regression Results

Variable	Number of Cases	Odds Ratio	95% Confidence Interval	P-value
Visit Factors				
1. Examinations Performed and Tools Used at Visit				
Performed Lifestyle Counseling				
No	6693		*Reference Group*	
Yes	2750	1.537	1.207 – 1.958	0.000*
Performed Neuropathy Examination				
No	8943		*Reference Group*	
Yes	500	1.663	1.093 – 2.532	0.018*
2. Laboratory Measurements Available at Visit				
ACR				
Not Measured	8949	0.525	0.367 – 0.751	0.000*
Normal (<=2.8 mg/mmol Female, <=2.0 mg/mmol Male)	270		*Reference Group*	
Triglyceride Levels				
Not Measured	8190	0.591	0.389 – 0.897	0.013*
Normal (<1.5mmol/L)	344		*Reference Group*	
Patient Factors				
1. Demographics				
Patient Gender				
Male	5173		*Reference Group*	
Female	4005	0.582	0.458 – 0.740	0.000*
2. Health Care Utilization				
Specialist Appointment in the Past 2 Years?				
No	5783		*Reference Group*	
Yes	2357	1.540	1.179 – 2.013	0.002*
Number of Years with Family Physician**	9443	0.975	0.956 – 0.994	0.012*

* Significant at the 0.05 level

** Continuous Variable

Note: Model Controls for physician ID, blood pressure, patient age, number of years with the family physician, A1C, ACR, Triglycerides, TC:HDL, LDL, patient gender, specialist appointment in the previous two years, drug benefit plan, type of glycemia treatment, smoking status, lifestyle counseling performed, neuropathy examination performed, eye disease diagnosis, nephropathy diagnosis, lipid problems, heart problems, obesity, diagnosed with another condition, total number of diagnoses, number of visits with the family physician during the study period.

Appendix D: Backward Stepwise Logistic Regression Results

Variable	Number of Cases	Odds Ratio	95% Confidence Interval	P-value
Visit Factors				
1. Examinations Performed and Tools Used at Visit				
Performed Lifestyle Counseling				
No	6693		*Reference Group*	
Yes	2750	1.526	1.198 – 1.943	0.001*
Performed Neuropathy Examination				
No	8943		*Reference Group*	
Yes	500	1.659	1.087 – 2.533	0.019*
2. Laboratory Measurements Available at Visit				
ACR				
Not Measured	8949	0.524	0.365 – 0.751	0.000*
Normal (<=2.8 mg/mmol Female, <=2.0 mg/mmol Male)	270		*Reference Group*	
Triglyceride Levels				
Not Measured	8190	0.590	0.388 – 0.896	0.013*
Normal (<1.5mmol/L)	344		*Reference Group*	
Patient Factors				
1. Demographics				
Patient Gender				
Male	5173		*Reference Group*	
Female	4005	0.579	0.454 – 0.739	0.000*
2. Health Care Utilization				
Specialist Appointment in the Past 2 Years?				
No	5783		*Reference Group*	
Yes	2357	1.538	1.173 – 2.017	0.002*
Number of Years with Family Physician**	9443	0.975	0.955 – 0.995	0.013*

* Significant at the 0.05 level

** Continuous Variable

Model Controls for physician ID, blood pressure, patient age, number of years with the family physician, A1C, ACR, Triglycerides, TC:HDL, LDL, patient gender, specialist appointment in the previous two years, drug benefit plan, type of glycemia treatment, smoking status, lifestyle counseling performed, neuropathy examination performed, eye disease diagnosis, nephropathy diagnosis, lipid problems, heart problems, obesity, diagnosed with another condition, total number of diagnoses, number of visits with the family physician during the study period.

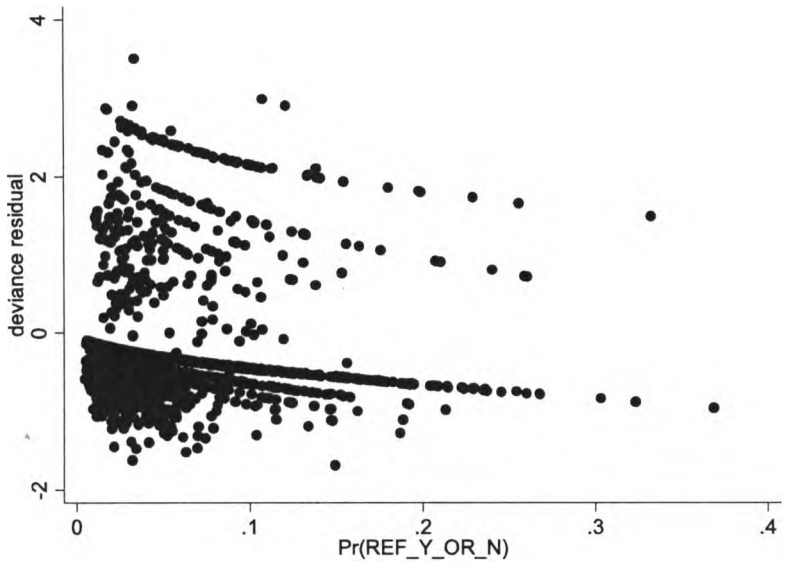
Appendix E: Regression Diagnostics

Diagnostic tests were performed for both the forward and backward stepwise regression model. Both models produced very comparable results. The results from the forward stepwise regression diagnostic tests will be reported.

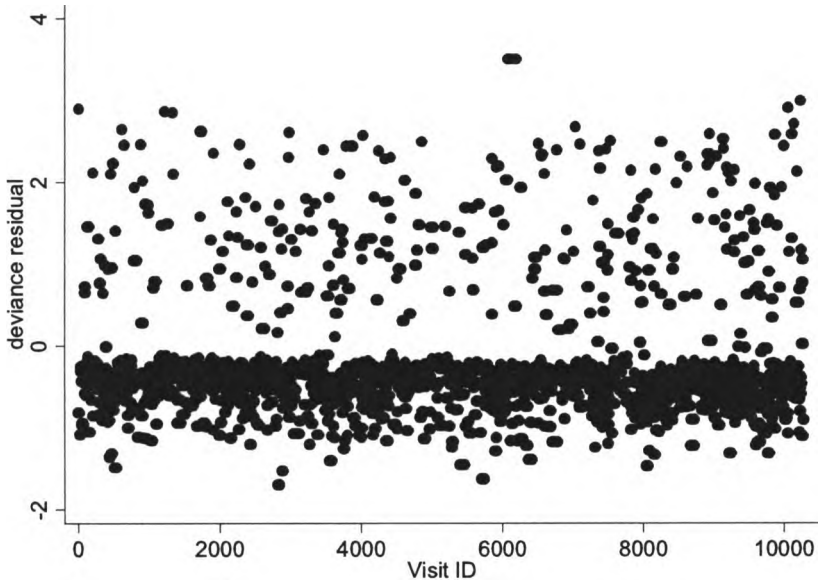
The pseudo r^2 for the forward stepwise regression model was 6.87%. The Hosmer-Lemeshow GOF Test resulted in a value of 1877.93 ($p = 0.2129$). This result indicates a well fitted model. The sensitivity of the model was 63.84%, specificity 67.38% and 67.25% of outcomes were correctly classified. The positive predictive value was 7.08% and the negative predictive value 97.95%. This indicates that the model may be poor at predicting when a referral would occur. The area under the receiver operating curve was 0.7177. This indicates that the model does have predictive value. The AIC and BIC were 2909.857 and 3260.356 respectively. See below for deviance residual plots and the receiver operating curve.

Deviance Residual Plot:

1. Deviance Residuals vs. Predicted Probability of Referral

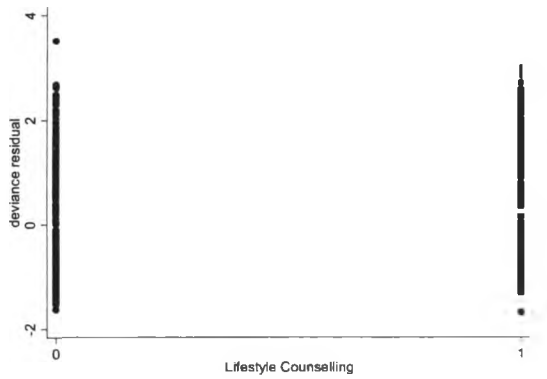


2. Deviance Residuals vs. Observation Number

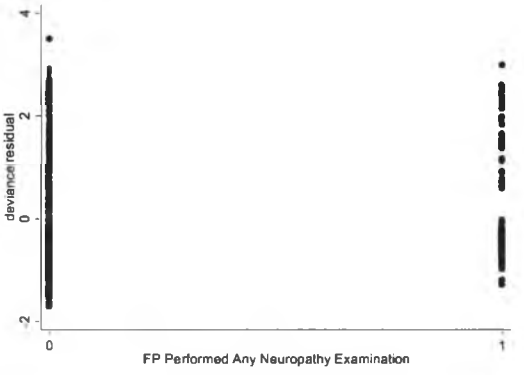


3. Deviance Residuals vs. Independent Variables

Lifestyle Counseling

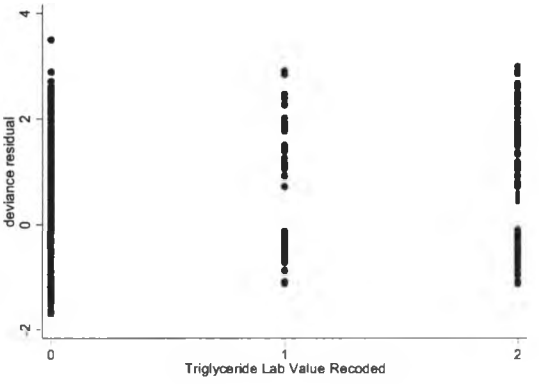


Neuropathy Examination

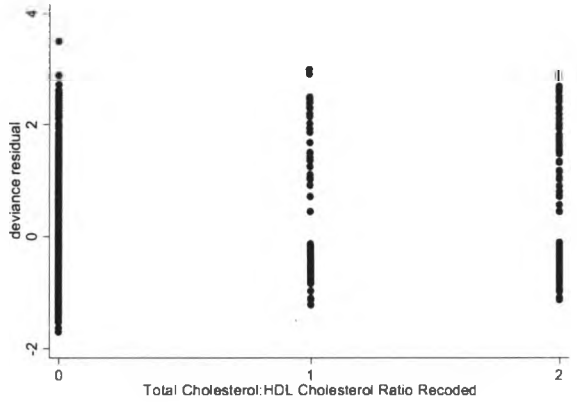


ACR Value

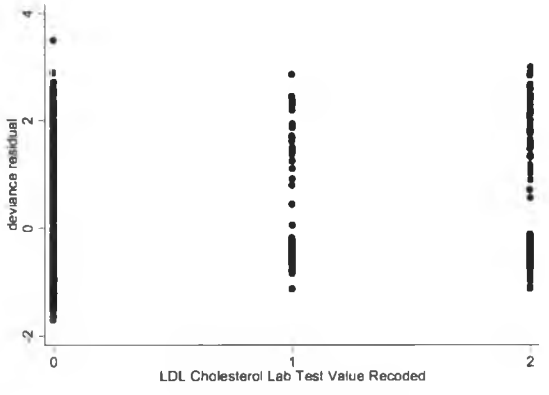
Triglyceride Value



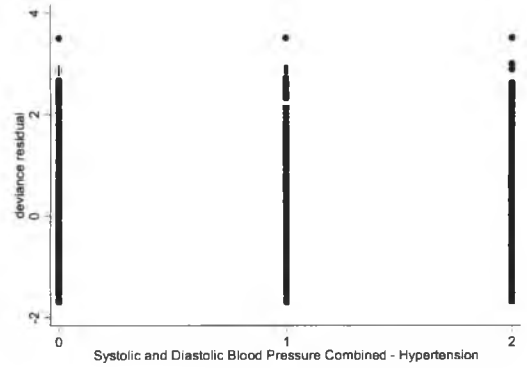
TC:HDL Value



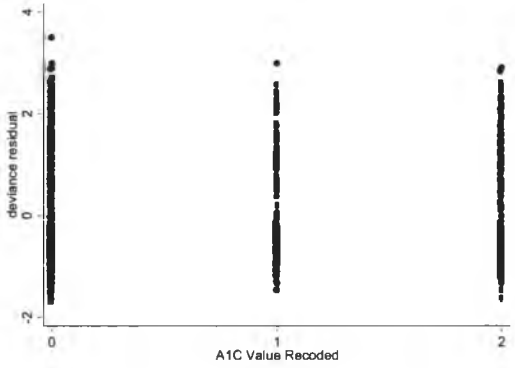
LDL Value



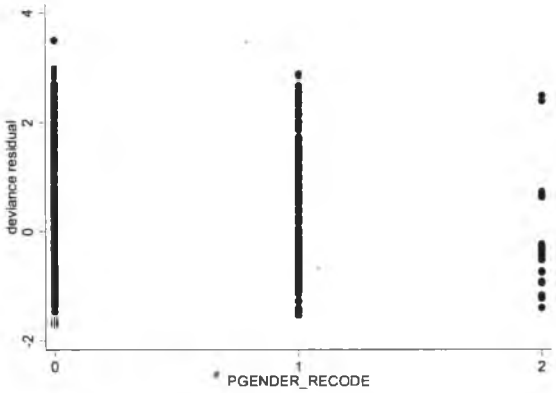
Blood Pressure



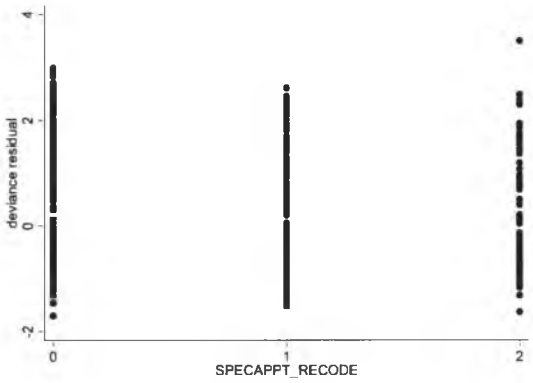
A1C Value



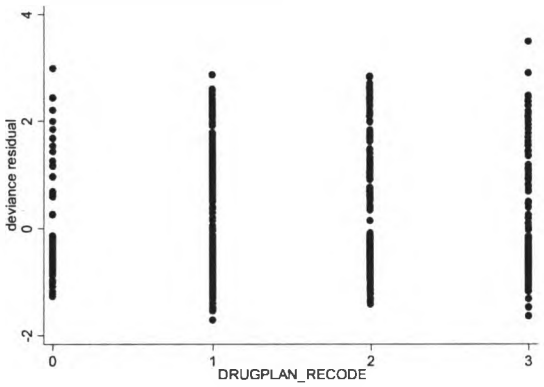
Patient Gender



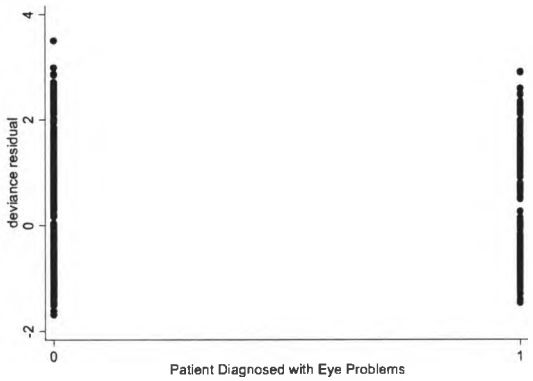
Specialist Appointment in the past 2 years?



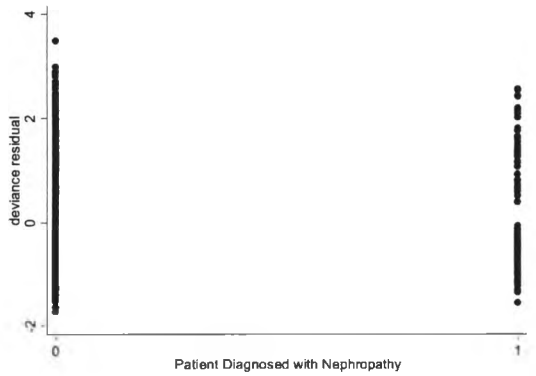
Patient Drug Benefit Plan



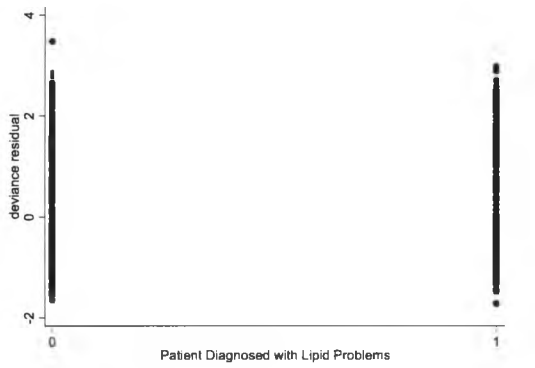
Diagnosed with eye problems?



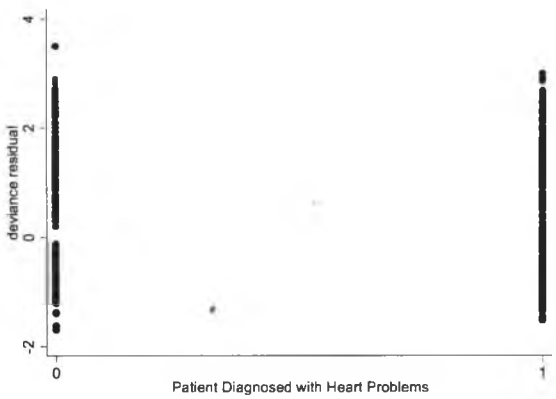
Diagnosed with nephropathy?



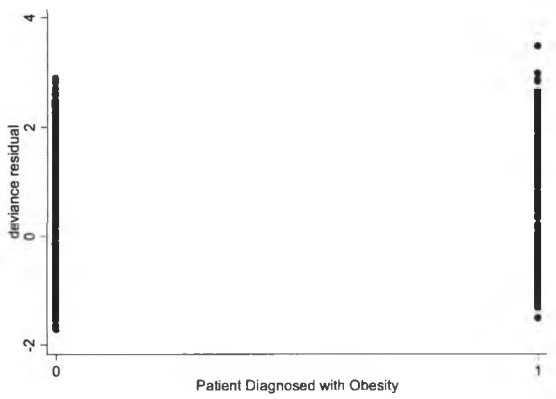
Diagnosed with lipid problems?



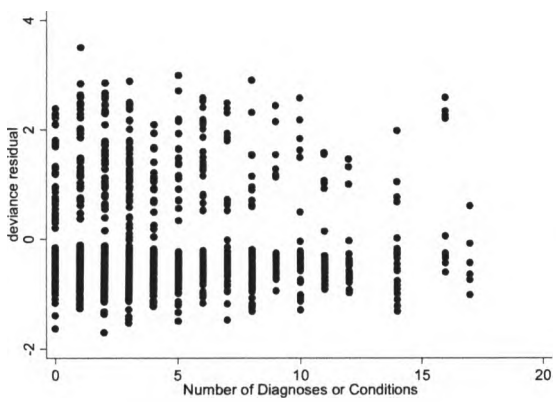
Diagnosed with heart problems?



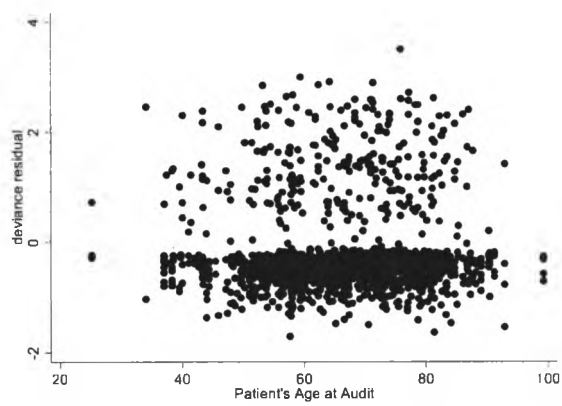
Diagnosed with obesity?



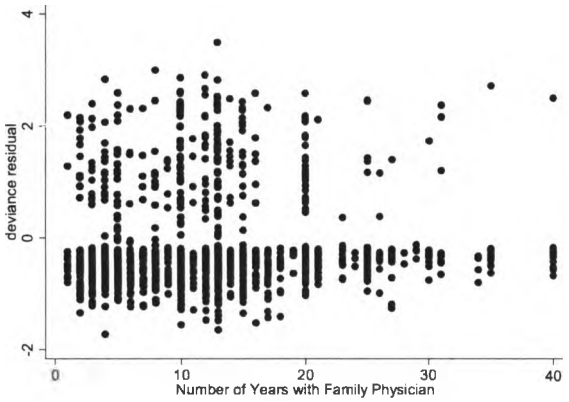
Number of Patient Co morbidities?



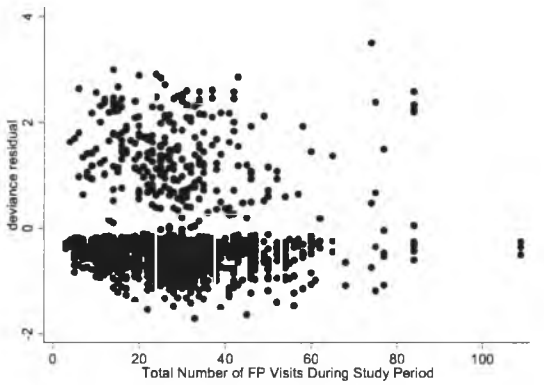
Patient Age



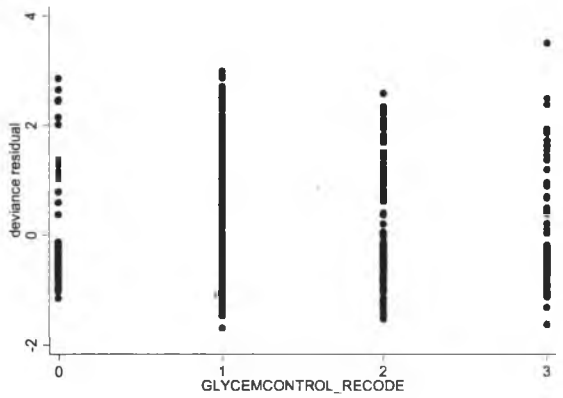
Number of years with the FP



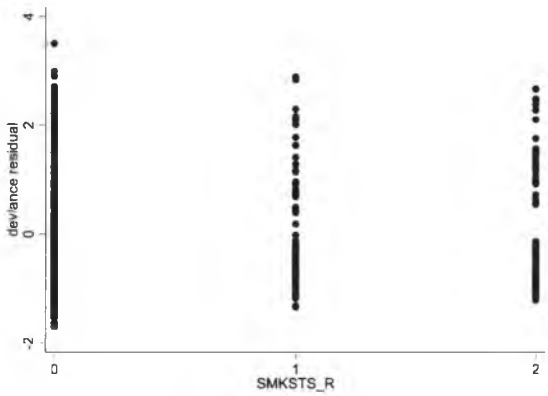
Number of visits during the study period



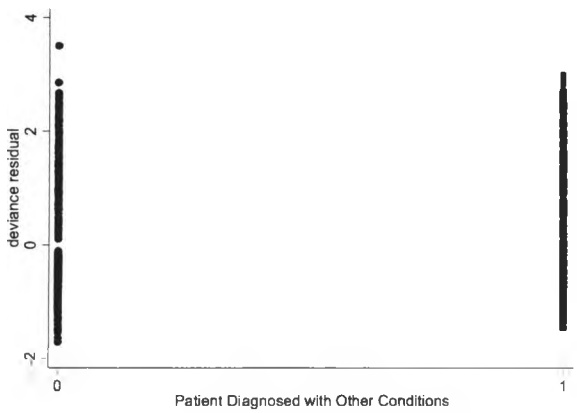
Type of Glycemia Treatment



Patient smoking status



Other Diagnosis



Receiver Operating Characteristic (ROC) Curve

The ROC curve is a plot of the sensitivity (true positives) vs. 1-specificity (false positives) of the forward stepwise binary logistic regression model. The area under the curve is 0.7177 indicating that the model is "fair" at distinguishing between visits that result in a referral vs. the visits that do not result in a referral.

Sensitivity vs. 1-Specificity