IMPACT OF DEPRIVATION ON THE MANAGEMENT OF DIABETES IN PRIMARY HEALTH CARE

by

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Abstract

Background: Socioeconomic factors and gender may influence the quality of care received by patients with diabetes. Millions of people are diagnosed with diabetes and rates are expected to increase. The management of diabetes in primary care is important in optimizing health for all.

Objectives: To investigate whether the selected diabetes quality of care indicators (haemoglobin A1c, low-density lipoprotein, blood pressure, abumin to creatinine ratio (ACR), and prescribed medication) are significantly different between those persons living in least and most materially and socially deprived neighbourhoods.

Methods: A cross-sectional study design with a population sample of patients with diabetes from a primary care practice in Southeast Ontario. De- identified patient data from electronic medical records were retrieved from the Canadian Primary Care Sentinel Surveillance Network. Combined material and social deprivation scores were based on the Pampalon Deprivation Index.

Results: The patients with diabetes largely resided in either the most or the least deprived neighbourhoods. Patients with diabetes living in the most deprived neighbourhoods were less likely than patients with diabetes living in the least deprived neighbourhoods to have their low-density lipoproteins within normal range (RR=0.84; CIs 0.73-0.98; p-value=0.026). There was no difference in management of diabetes between least and most deprived patients with diabetes regarding haemoglobin A1c, blood pressure, ACR, and medication prescribed; these were

positive result for the clinical practice. Women with diabetes were less likely than men with diabetes to have their low-density lipoproteins under control (RR=0.71; CIs 0.62-0.81; p-value <0.001) and be prescribed ACE inhibitors or ARBs (RR=0.79; CIs 0.69-0.90; p-value <0.001). However, women with diabetes were more likely to have their most recent haemoglobin A1c within normal range (RR=1.24; CIs 1.10-1.40; p-value <0.001) and have their most recent ACR within normal range (RR=1.25; CIs 1.05-1.50; p-value=0.015).

Conclusion: This study found that the quality of care for patients with diabetes was not influenced by whether a person lived in a deprived neighbourhood or not. However, the study identified some important gender differences related to whether a person's diabetes was under control. The reason for these differences is unknown.

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Table of Contents

List of Tables

List of Figures and Illustrations

Chapter 1: Introduction

1.1 Background

The World Health Organization adopted a constitution in 1946 stating that "the highest standard of health should be within reach of all, without distinction of race, religion, political belief, economic or social condition". Ideally, everyone could attain their full health potential and no one should be disadvantaged from achieving this potential because of their socially determined circumstances[1].

Differences in health that are systematic, socially produced and unfair are considered to be inequities in health. One method to illustrate existing health inequity in a society is to show the systematic difference in health outcomes between different socioeconomic groups [2]. The management of a chronic condition such as diabetes mellitus can be used as a model to illustrate these health inequities.

The number of individuals with diabetes mellitus in Canada is growing rapidly because of an aging population, immigration from high-risk groups, and increasing aboriginal population[4]. The effectiveness of care of the major chronic diseases, however, has been significantly improved because of recent progress in both clinical and behavioural interventions. Yet, there are patients with diabetes who are not enjoying the full benefit of these recent improvements[3]. Socioeconomic status of an individual is an important additional consideration other than the immediate health status in the management of diabetes. Past and recent literature has shown how socioeconomic factors shape the health of an individual[1,2,19,20]. In

respect to diabetes specifically, Raphael et al., Kelly et al., Sigfrid et al. and others have demonstrated that socioeconomic factors greatly influence the prevalence and management of diabetes [19,33,34,35,42]. For example, people living in most deprived neighbourhoods were 1.6 times more likely to have diabetes and less likely to be on target with haemoglobin A1C than those living in least deprived neighbourhoods[33,34]. Results were based on patients with diabetes in Europe who visit primary care clinics or were part of a diabetes registry.

The purpose of this study was to compare the management of people with diabetes in Southeastern Ontario among different socioeconomic strata and between genders. Socioeconomic strata were measured using the Pampalon deprivation index; which scores individuals across a spectrum of social and material deprivation. Data were collected from the Canadian Primary Care Sentinel Surveillance Network (CPCSCN) regarding physiological measures, laboratory test results, prescription medications, and comorbid conditions.

1.2 Rationale

Despite the tremendous progress in the clinical interventions to improve care, health disparities are still evident and so actions beyond the healthcare system are needed. A holistic approach incorporating the social determinants of health is essential in reducing health inequities and improving quality of care. The burden of disease and its risk factors are spread unequally across the Canadian population, with the most materially and socially deprived individuals having higher mortality and morbidity rates[19]. The low income Canadians are predisposed to material and social deprivation and are more commonly diagnosed with adult onset diabetes[44]. Deprivation and developing diabetes often leads to poor management of

diabetes because of factors such as food insecurity and social exclusion. Food insecurity and poor diet choices lead to dietary deficiencies and poor management of the disease[44]. These health inequities are unfair and socially produced and are, therefore, modifiable and can be improved.

In this study, diabetes is an ideal condition to be used as a model to illustrate health inequities because there is extensive primary care data collected on individuals with diabetes; research had been done on the disease and its comorbidities related to prevention and management; there is limited research done on how deprivation influences diabetes management in Canada; and finally, there are system-based incentives encouraging standardized care. A payment is available to physicians for completing a flow sheet to help in coordinating, providing and documenting elements of care for patients with diabetes as outlined by the Canadian Diabetes Association Clinical Practice Guidelines[29]. That is to say, primary care providers are encouraged to provide standardized care and to improve the health of patients with diabetes regardless of their level of deprivation.

This study addresses some of the limitations of past studies by selecting a strong source of primary care information such as the CPCSSN that is based on electronic medical records, and utilizing a comprehensive method of attributing level of deprivation such as the Pampalon deprivation index.

Unlike most other studies, this study uses electronic medical records (EMR) in place of administrative data to assess the extent of health inequity and diabetes. EMRs are recognized as a valuable source of health information for research that is not readily available from other

sources[19]. EMR data is proven to be more comprehensive and reliable compared to other source of health data when conducting research on chronic conditions[24]. Since this study relies on detailed health results, it was important to use an EMR database. CPCSSN is able to provide the high quality and detailed clinical information needed for this investigation. Provider information, patient demographics, physical examination, risk factors, referrals, laboratory tests, procedures and medications data are all available from CPCSSN[24].

Past studies that examined the relationship between health outcomes and deprivation often used a single measure of deprivation, most common of which was average neighbourhood income.[6,19] Income alone does not represent an individual's level of deprivation; it ignores the social aspect of deprivation. In this study, the Pampalon deprivation index was used to rank individuals on a spectrum of deprivation. Unlike other indices, the Pampalon deprivation index is a validated index that considers social and material deprivation[20].

1.3 Study Objectives

The aim of this study was to assess the management of patients with diabetes in Southeastern Ontario among deprivation quintiles as defined by the Pampalon deprivation index. Specifically, whether the diabetes quality of care indicators (listed below) are significantly different between those least and most materially and socially deprived (**objective 1**) and between males and females (**objective 2**).

List of outcomes of interest

Whether the patient diagnosed with diabetes had the following indicators Recorded (or not) in their electronic medical record:

- haemoglobin A1c within the past 12 months
- low-density lipoprotein within the past 12 months
- blood pressure within the past 12 months
- albumin to creatinine ratio within the past 12 months
- ACE-1 or ARB within the past 12 months

Whether the patient diagnosed with diabetes is on target (or not) on following quality of care indicators:

- haemoglobin A1c <7.0% within the past 12 months
- low-density lipoprotein <2.0 mmol/L within the past 12 months
- blood pressure <130/80 mmHg within the past 12 months
- albumin to creatinine ratio <2.0 mg/mmol for males and <2.8 mg/mmol for females

The primary hypothesis is that people living in most deprived neighbourhoods are more likely than people living in least deprived neighbourhoods to experience lower quality of primary care for diabetes management. In addition, despite the lack of information about the gender differences in the quality of care received by people with diabetes, for the purposes of this study, it was also hypothesised that quality of primary care would differ between men and women with diabetes.

Chapter 2: Literature Review

2.1 Diabetes in Canada

2.1.1 Rate of Diabetes in Canada

Diabetes mellitus is a chronic disease that potentially leads to serious complications. It was estimated in 1985 that 30 million people were diagnosed with diabetes worldwide; in 2000 that number increased to over 150 million people[4]. The future predictions indicate that this number will increase even further to 380 million in 2025 if current trends continue[4]. The World Health Organization listed diabetes mellitus as one of the top ten leading causes of death in the world, especially in high-income countries[5]. The impact of diabetes is so great that the United Nations General Assembly Passed a resolution in 2007 identifying November 14th as World Diabetes Day for the purpose of developing strategies and policies for prevention and treatment of individuals diagnosed with diabetes[6].

Rates of diabetes in Canada are also increasing at alarming rates. About 1.1 million individuals had been diagnosed with diabetes in 1998, which is a prevalence of 4.8% [7]. In 2008, the prevalence rate increased to 6.8%, with 2.4 million adults diagnosed[7]. Diabetes rates are expected to further increase because of an aging population, immigrations from high-risk populations and a growing Aboriginal population[4].

2.1.2 Impact of Diabetes on the Canadian Healthcare System

Diabetes and its potential complications put a strain on the healthcare system in both cost and services[4]. Due to poor management of diabetes, there is an increase in cost of primary

healthcare and an increase in waiting times for treatment in emergency departments[4]. In 2006, about 10% of hospital admissions were related to diabetes and its complications[4]. This can be improved by delivering a more effective and targeted care to those who are most deprived since they often have poor management of diabetes.

Diabetes leads to many serious comorbidities and complications. In Canada, diabetes is the leading cause of a number of other comorbidities in adults including: blindness, end-stage renal failure, cardiovascular diseases, and non-traumatic amputations[4]. The leading cause of mortality in individuals with diabetes is cardiovascular diseases, which occurs four times more often in individuals diagnosed with diabetes compared with individuals without diabetes[6]. The seriousness of diabetes becomes even more apparent when considering that about 15 to 25% of individuals with diabetes are diagnosed with depression, which further increases the risk of poor compliance with treatment and increases the healthcare costs[6]. In 2005, the government spent $5.6 billion for the treatment of diabetes and its complications, 10% of the annual cost of Canada's healthcare system[9]. The services include: specialist and primary care physician visits, surgical and emergency care, medication, devices and supplies used in hospitals. However, it does not include the increased costs of rehabilitation after surgery, the personal cost to the individual and their families, and the overall loss of productivity[9].

2.1.3 Diabetes and Gender

It is important to study gender differences because women and men have different patterns of disease, disability and mortality[10]. The prevalence of diabetes is believed to be

higher among men than women (7.2% and 6.4% respectively)[7]. However, in the past decade, women have experienced the greatest increase in diabetes prevalence[10]. Young women have a higher lifetime risk of diabetes complications because of an earlier diagnosis and face issues related to their reproductive system and complications during pregnancy because of diabetes[10]. The results of a large Canadian study, the Power Study, show that women had worse health and functional status than men due to diabetes[10]. Women with diabetes have higher rates of comorbidity compared to men with diabetes (63% vs. 51%). Women with diabetes also have higher rates of depression (11.1% vs. 4.3%) and report poor instrumental activities of daily living and activities of daily living compared to men with diabetes (49% vs. 27%)[10].

On the other hand, young men with diabetes and men with diabetes living in low-income neighbourhoods were more likely to visit hospitals for emergency management of their diabetes, which can be avoided through access of outpatient services and improved self-management[10].

2.2 Diabetes as a Chronic Condition

Diabetes is a chronic condition that occurs when the blood glucose level is abnormally high due to either deficiency of available and effective insulin or deficiency in insulin action[49]. Insulin can be lacking due to the inability of the pancreas to produce enough insulin. On the other hand, deficiency in insulin action is seen mostly in type 2 diabetes with insulin resistance[49]. Insulin resistance occurs when the normal biological response to insulin is reduced and higher levels of insulin are needed to reach the proper effects. While the pancreas can produce normal or above normal amounts of insulin, the body is in needs of more insulin to

overcome the insulin resistance; this is one of the main characteristics of type 2 diabetes. If the pancreas was able to produce the additional insulin needed, then the individual's condition of type 2 diabetes would be clinically unapparent. However, if the pancreas cannot produce the additional insulin needed, then this leads to hyperglycaemia and, therefore, type 2 diabetes[49]. The end result of deficiencies of insulin availability and insulin action is the body's inability to utilize glucose effectively and consequently the body suffers from lack of energy. As the body is in need of fuel, glucose levels in the blood rises because it is not being absorbed. The body then turns to other sources of fuel, such as stored glycogen, fat and protein. Therefore, as the glucose levels in the blood raises, so does the levels of fats[49].

2.2.1 Types of Diabetes

There are two common types of diabetes: type 1 and type 2 diabetes. Type 1 and type 2 diabetes differ in their pathophysiology, but both result in high blood glucose levels and increase the risk of developing the same complications[51]. Type 1 diabetes results from the inability of the pancreas to produce insulin due to the destruction of insulin-producing β–cells in the pancreas. Autoimmune processes lead to this destruction of β–cells. Viral infections, chemical toxins, and other diseases have been associated with this autoimmune response[51]. On the other hand, type 2 diabetes is a sum of abnormalities involving glucose metabolism and other metabolic processes. The majority of individuals with diabetes mellitus have type 2 diabetes (about 90%)[49]. The main characteristic of this type is insulin resistance which leads to an increased production of insulin to compensate. In the early stages, the pancreas is able to meet the needs of larger quantities of insulin. Over time, the number of insulin producing β–cells declines and the pancreas can no longer accommodate for the increasing need of insulin.

Other than abnormalities in glucose metabolism, hypertension, dyslipidemia, hypercoagulability, and abdominal obesity also contribute to the development of type 2 diabetes. The collection of these abnormalities is referred to as the metabolic syndrome[49].

Other types of diabetes include diseases that are drug or chemically induced, infections, and immune or genetic conditions. Impaired glucose tolerance (IGT) and impaired fasting glucose (IFG) are types of diabetes that describe individuals with borderline diabetes. They increase the risk of future development of type 2 diabetes and increase the risk of macrovascular disease[49]. Another type of diabetes is gestational diabetes mellitus (GDM) where glucose metabolism abnormalities are diagnosed or has its onset during pregnancy. GDM may be a result of the development of type 1 diabetes during the time of pregnancy or it may increase the risk of developing type 2 diabetes after pregnancy[49].

Left untreated or managed poorly, diabetes mellitus can lead to many serious complication including cardiovascular and cerebrovascular diseases, kidney disease, retinopathy, and nerve damage[4]. People with diabetes are at a very high risk of developing vascular diseases and the mortality rate of the ones who develop vascular diseases is up to 80%[4]. High blood glucose levels and high blood pressure can severely damage the kidneys and hinder their function. The majority of people with diabetes for 15 years or more will develop kidney disease[4]. Diabetic retinopathy is another serious complication and is the leading cause of blindness in people age 65 years and younger in North America[4]. Finally, nerve damage, or neuropathy, occurs over time as sensory nerves are damaged without proper regeneration

especially in the hands and feet. This makes it more difficult to recognize any foot injury and left untreated, the injury can become infected and at times leading to amputation[4].

2.2.2 Treating Diabetes

There are many tools for the treatment of diabetes including: education, activity, nutritional therapy, oral hypoglycemic medication and insulin. Achieving the desired outcome is usually multifactorial[4]. Education and exercise are a vital part in the success of most methods of managing diabetes. Individually they are not sufficient to control diabetes, but are able to improve the efficacy of other tools of treatment when combined together. Exercise itself is beneficial because it leads to better general health and reduced insulin resistance[49]. The regulation of nutritional intake is also crucial to managing diabetes by regulating blood glucose levels. Furthermore, there is a wide range of medications that can aid in increasing insulin sensitivity, slowing gastrointestinal absorption of carbohydrates, and restoration of incretin function. Synthetic human insulin and insulin analogs are also used when insulin is no longer produced (or is not sufficient) by the pancreas[51].

2.3 Management of Diabetes in Primary Healthcare

The Canadian Diabetes Association published the '2008 Clinical Practice Guidelines for the Prevention and Management of Diabetes in Canada'[4]. The guidelines are mostly evidence-based and aim to achieve optimal care for individuals with diabetes[4]. Blood glucose, blood pressure, blood lipids, body mass index, foot care, and eye care are among the many elements that need to be regularly monitored by healthcare teams to achieve an effective management of diabetes[4].

2.3.1 Blood Glucose Control

Haemoglobin is an oxygen carrying molecule in red blood cells. Glucose adheres to haemoglobin to form glycosylated haemoglobin (haemoglobin A1c). Because red blood cells survive in the body for about three months, haemoglobin A1c can be used to measure the average plasma glucose concentration over that period of time[4]. Elevated blood glucose results in higher haemoglobin A1c levels, indicate poor control of blood glucose level[4]. The normal range for patients with diabetes is ≤7.0%. The haemoglobin A1c testing is recommended every 3 months when glucose targets are not met and when diabetes therapy is being adjusted, and every 6 months when glucose target are met[4].

2.2.2 Blood Pressure Control

Most patients with diabetes will develop hypertension which leads to higher risks of developing microvascular and macrovascular complications. Hypertension is a treatable risk factor, however, there is an increase in risk of cardiovascular morbidity and mortality if there is a delay in its recognition and management. Therefore, it is recommended that patients with diabetes have blood pressure measured at every diabetes related clinical visit and be treated aggressively if blood pressure is elevated. The suggested blood pressure target range is <130/80 mmHg[4].

2.3.3 Blood Lipid Control

Assessing low-density lipoproteins (LDL) is necessary in patients with diabetes since diabetes and elevated LDL are both associated with higher risk of cardiovascular disease (2 to 4 folds greater than that of individuals without diabetes)[4]. Patients with diabetes often develop

risk factors that lead to cardiovascular disease and one of which is high levels of LDL; others include hypertension and low levels of high-density lipoproteins. Cardiovascular disease is also the primary cause of death among patients with diabetes. Clinical assessments can identify patients with diabetes with high risk of cardiovascular disease. The primary target for most people with diabetes is an LDL of $\leq$2.0 mmol/L[4]. It is recommended that LDL levels be periodically rechecked annually or earlier as needed[4].

2.3.4 Screening for Chronic Kidney Disease

Chronic Kidney Disease (CKD) is one of the most common complications of diabetes; about 50% of people with diabetes are diagnosed with CKD[4]. CKD associated with diabetes is the leading cause of kidney failure in Canada. Patients with diabetes can be assessed for their risk of CKD with albumin creatinine ratio (ACR). ACR measures the ability of the kidney to filter protein and gives an early indication of diabetic nephropathy development. It is recommended that patients with diabetes be screened annually[4]. The suggested target range for men is < 2.0 mg/mmol and < 2.8 mg/mmol for women[4].

2.3.5 Angiotensin Converting Enzyme Inhibitor, Angiotensin Receptor Blockers (ACE/ARB)

The first priority in the prevention of diabetic complications is the reduction of cardiovascular risk[4]. This can be achieved through a comprehensive approach of lifestyle interventions and prescribed medications. Prescription of angiotensin converting enzyme (ACE) inhibitors or angiotensin II receptor antagonists (ARBs) for patients with diabetes is aimed to control blood pressure as well as reduce the risk of cardiovascular diseases and nephropathy[4]. For patients with diabetes with a blood pressure >130/80 mmHg it is recommended to

prescribe ACE inhibitors or ARBs in addition to lifestyle interventions. Patients with diabetes with albuminuria (ACR $\geq$ 2.0 mg/mmol in men and $\geq$2.8 mg/mmol in women) should be treated with an ACE inhibitor or an ARB as initial therapy[4].

Other than the clinical care, efforts from the community and the individual are essential for improving the quality of care of diabetes[3]. For example, individuals with diabetes need to have adequate self-management skills[13]. Self-management requires the individual to be educated in their condition (i.e. know the cause of diabetes and how to manage diabetes) and have the financial ability to meet those needs (i.e. healthy diet)[12]. In other words, an individual with diabetes needs food security, literacy, and social support networks to be able to improve their health[1], which is obviously problematic for those that are most deprived as these are the very things they are deprived of. There needs to be a multidisciplinary approach beyond the healthcare system and the Chronic Care Model illustrates this (Appendix 1).

2.4 The Chronic Care Model

Chronic conditions are defined as any conditions that require ongoing adjustments by the patient and interactions with the healthcare system[3]. The effectiveness of care of major chronic diseases has drastically improved by recent progress in clinical and behavioural interventions[3]. However, a significant number of individuals are not experiencing the benefits of this recent progress[3]. The current healthcare system is challenged in delivering optimum quality care for chronic diseases due to: lack of care coordination, lack of active follow-up to

ensure optimal outcomes, practitioners not following practice guidelines, and inadequately trained patients on managing their own condition[13]. The current Canadian healthcare system is designed to treat short-term illnesses, injuries and infections and is less equipped to meet the needs of the chronically ill population[28]. The Chronic Care Model was developed as a system redesign strategy to adequately address the continuous care needs of the chronically ill population[28].

The Chronic Care Model was first introduced by Edward Wagner and colleagues in 2001 and since then it had gained great interest in many countries to improve chronic illness care[11]. It has been implemented in the United Kingdom, United States, Australia and recently Canada[28]. The Ministry of Health in British Columbia adopted this model in 2000 to address the expanded role of government and community in the Canadian healthcare system[28]. Alberta, Saskatchewan and Ontario are also implementing versions of this model[28].

The model outlines a collective effort by the community, health practice, and patient to encourage cost effective and optimal quality of chronic illness care. The goal is to deliver care that is effective, efficient, equitable and patient-centered[11]. Specifically, there are six elements to the model: the community, the healthcare system, self-management support, delivery system design, decision support, and clinical information systems. Evidence-based changes of each element foster a 'productive interaction' between informed patients (who are also active participants in their care) and healthcare providers who have resources and expertise[3].

2.5 Social Determinants of Health

2.5.1 Social Determinants of Health and Health inequities

The conditions in which people are born, grow, live, work and age (including the health care system) are referred to as social determinants of health; it is a general term used to encompass the social, economic, political, cultural and environmental determinants of health[1]. Action across all these sectors is required to promote well-being[1]. Both, the Declaration of Alma Ata adopted by the International Conference on Primary Health Care and the Ottawa Charter of Health Promotion, have called for action on social determinants of health to improve well-being[1]. The most important of those determinants are those that create stratification within society called 'structural determinants' which include: income, gender, ethnicity, disability, and political structures that reinforce inequalities (Appendix 2)[1]. These determinants position individuals into hierarchies of power, prestige, and access to resources[1]. The mechanisms that produce and maintain this stratification are the same mechanisms that are responsible for inequities in health. The mechanisms include: governance structure, education and financial systems, labour market, social provision and protection. The social position is important because it shapes individuals' health status and health outcomes through its impact on 'intermediary determinants' which include: living conditions, psychosocial circumstances, behavioural and biological factors, and the healthcare system[1].

Therefore, to improve well-being and reduce inequities in health, a social determinants approach is preferred. Specifically, the determinants that create and influence social stratification need to be addressed. In return, better health will contribute to societies' productivity, economic development, cohesion, education and well-being; it is a cycle. A social

determinants approach identifies health distribution as measured by the degree of health inequity which can be used as an indicator of societies overall functioning[2].

Gram and Kelly (2004) suggest the approach to reducing health inequity is "improving health of the most disadvantaged individuals by focusing on the improvement of social conditions and reducing risk factors"[14]. This approach is advantageous because it focuses the attention on marginalized groups who may have been previously excluded and it allows for monitoring and evaluation of interventions that are focused on this specific population[14]. Aiming to reduce health inequities by focusing on most disadvantaged groups may be beneficial to everyone[14].

2.5.2 Income and Mortality

There is no doubt that social determinants have a strong impact on health[1,2,8]. To demonstrate health inequities, the social determinate of income is often used to illustrate that individuals of varying income also have varying health outcomes. Income inequality has increased since 1980 in Canada and the situation was exacerbated with the economic recession that began in 2008[16]. A study by Wilkins et al. (2007) demonstrated that the lifespan of Canadians depends on the average income of their neighbourhoods[17]. Men living in the poorest 20% of urban neighbourhoods in Canada live four and half years less than those in the wealthiest 20% of neighbourhoods (women live two years less) [17]. In another study by Kanjila et al. (2006) suggests that diabetes prevalence increased with increasing deprivation, but peaked in most deprived groups[18].

Mortality can also be used to illustrate health inequity. Figure 1 illustrates that death rates across social economic classes are different for persons with diabetes. In a study done by Wilkins et al., both, mortality rates of diabetes and health inequities are increasing[19]. There was no difference in death rates of people with diabetes among neighbourhoods from 1970s till 1980s, but death rates began to increase significantly in the low-income neighbourhoods compared to the high-income neighbourhoods[19]. The authors report that these changes are not due to the aging of the population because the data was age adjusted[19]. Socioeconomic factors are reported to be the driving factors of these changes from 1970 to 1980[19]. The increase in income inequality in Canada since 1980 and the lack of affordable housing had played a major role in the illustrated increase of diabetes related mortality among the low-income neighbourhoods[19].

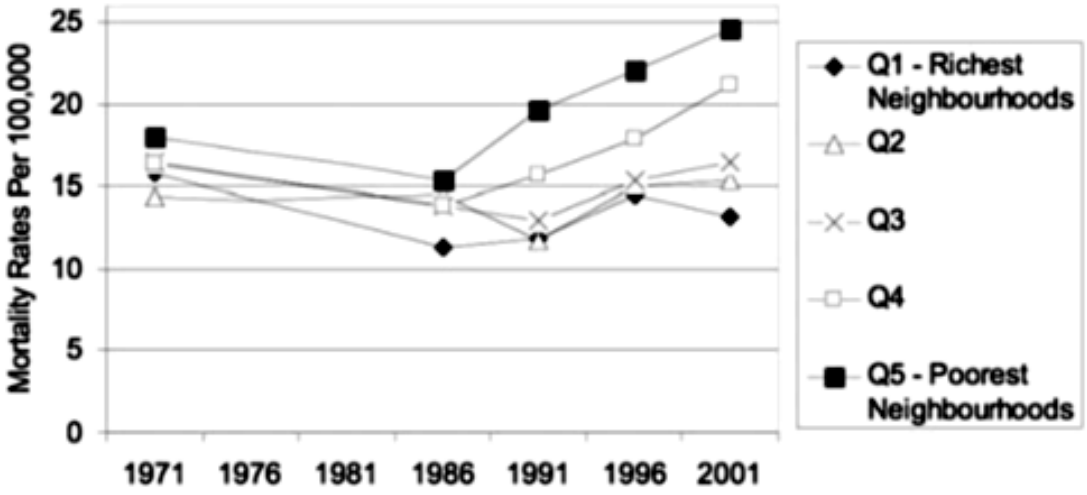


Figure 1. Male diabetes mortality in urban Canada from 1971-2001. Adapted from "Health Inequities in Canada," by Raphael D., 2010, Social Alternatives, 29, p.43.

2.5.3 Social Determinates of Health and Diabetes

It is important to consider the social determinants of health when trying to understand the care of diabetes[43]. Social determinants of health include the contextual factors in which persons with diabetes live, such as features of neighbourhoods and individual factors like social support and exclusion [43]. The Canadian Facts (2010) report stresses the importance of social determinants of health as the primary factors that shape the health of Canadians. One of the social determinants of health discussed was income[44]. Low income Canadians are predisposed to material and social deprivation and are more commonly diagnosed with adult onset diabetes[44]. Deprivation and developing diabetes often leads to poor management of diabetes. Another determinant of health is food insecurity, which refers to the individuals who are unable to have adequate diet in terms of quality and quantity. Food insecurity leads to inadequate nutritional intake; a diet poor in fruits and vegetables, milk products and vitamins[44]. Dietary deficiencies are more common among food insecure households and are associated with increased likelihood of chronic diseases and difficulties in managing these diseases[44]. Diabetes is more common in food insecure households even when factors of age, sex, income, and education were taken into account[44]. Food insufficient households were 80% more likely to report having diabetes than households with sufficient food[44]. Social exclusion is another important determinant of health. Social exclusion refers to specific groups being denied the opportunity to participate in Canadian life by having limited access to social, cultural, and economic resources[44]. Studies found that marginalization and exclusion of individuals and communities from mainstream society is a leading factor to adult onset diabetes and other chronic disease[44].

2.5.4 Deprivation, Patient Sex and Diabetes

There are a limited number of published studies that assessed the association of deprivation and patient sex with quality of care received by patients with diabetes in primary care[33]. One study done in the United Kingdom by Hippisley-Cox and colleagues (2004) used neighbourhood-level deprivation data to proxy individual deprivation. The study assessed the association between deprivation, ethnicity and sex with quality of care indicators for diabetes in a sample of 53 000 patients with diabetes from primary care[33]. The purpose of the study was to determine the effect of deprivation and ethnicity on the achievement of indicators for patients with diabetes and the extent of inequalities between men and women[33]. Adjusted odds ratios were reported for 18 indicators for diabetes care were compared for patients from most to least deprived neighbourhoods and between men and women. Compared to least deprived neighbourhoods, patients from most deprived neighbourhoods were less likely to have body mass index, smoking status, haemoglobin A1c level, blood pressure and retinal screening recorded[33]. Patients who were most deprived were also less likely to have haemoglobin A1c levels at target when compared to least deprived patients[33]. On the other hand, women with diabetes were significantly less likely to have body mass index, blood pressure, and cholesterol concentration recorded compared to men with diabetes[33]. Women were also less likely to be at target with blood pressure and cholesterol compared to men with diabetes[33]. The study concluded that primary care in areas of high deprivation was less likely to achieve the quality indicators for diabetes[33].

Another key study was done by Sigfrid L. and colleagues (2006)[42]. The study assessed the 'exception reporting' rates for 15 diabetes indicators using the Quality and Outcome Framework data (a payment system to encourage general practitioners to use evidence-based interventions in the management of chronic conditions) for 49 primary care practices in the United Kingdom and related it to a deprivation ranking for each practice. 'Exception reporting' specifies that a patient does not meet the expected clinical indicator criterion, such as intolerance to medications and not attending clinic after invitation[42]. This is to ensure that practices are not unfairly penalized, but at the same time it may reduce the standards of care given to those identified patients and lead to an increase in health inequality[42]. The authors found that diabetes prevalence was 26% higher in the most deprived neighbourhoods compared to the least deprived neighbourhoods. Also, correlations between 'exception reporting' and deprivation were seen for most diabetes indicators, such as ACR, haemoglobin A1c, smoking status, blood pressure and rental screening[42]. The study however did not find significant correlation between achievement of targets for any diabetes indicators and deprivation[42].

Other studies done by Kelly W. et al (1993) and Evans, J. et al. (2000) found differences in blood glucose control and body mass index among patients with diabetes and concluded that socioeconomic status of an individual affected the prevalence and management of diabetes[34,35]. People in the most deprived neighbourhoods were 1.6 times more likely to have diabetes than those people living in least deprived neighbourhoods and the body mass index of patients with diabetes increased as deprivation increased[33,34]. These results were based on thousands of patients with diabetes from Europe who visit primary care clinics or were part of a

diabetes registry that gathered information from hospital administration and primary healthcare clinics.

2.6 Pampalon Deprivation Index: Ranking Individuals into their Societal Position

Past epidemiologic studies that examined the relationship between health outcomes and the individuals' social position used census data and indices to rank individuals into a spectrum based on selected indicators of social status (usually average income). For example, research studies would identify the average income within a specific geographic area (such as neighbourhoods). Each of these geographical areas were placed into equal population sized groups (such as quartiles or quintiles) ranging from wealthiest to poorest according to census indicators of average income. The study would then collect administrative health data of those residing in these areas. Finally, the health status among these groups was compared. Health inequity will be evident if there was a lack of consistency of health status among the groups/socioeconomic strata (see Figure 1 for an example). The large limitations of most studies was that they focus on using only one indicator of social disparity (average neighbourhood income), use administrative data, and they often use mortality alone as an indicator of health.

For this proposed study, the Pampalon deprivation index will be used to rank the geographical areas from least to most deprived. There are advantages of using the Pampalon deprivation index in this study. It is a validated index that can be applied to national Canadian data or data from specific cities[20]. Unlike other indices, the Pampalon deprivation index was developed in Canada and, therefore, is applicable to the unique Canadian databases[20]. In

addition, it takes into consideration more than income as an indicator of social deprivation. Peter Townsend (1987) defined deprivation as "a state of observable and demonstrable disadvantage relative to the local community or the wider society or nation to which an individual, family or group belongs." The disadvantages are classified into either social or material[21].

The Pampalon deprivation index uses a compilation of six standard census indicators that have a relationship with health and well-being to characterize the levels of social and material deprivation[20]. Material deprivation refers to the inability of individuals to afford modern day goods and conveniences. The census indicators for material deprivation are: proportion of persons who have no high school diploma, employment to population ratio and the average income of persons aged 15 and over[20]. Social deprivation refers to the vulnerability of an individual's social network. The census indicators for social deprivation are: proportion of persons aged 15 and over who are separated, divorced or widowed, proportion of persons living alone, and the proportion of single-parent families[20]. These indicators are selected because they meet four criteria: are linked to health, previously used as geographic proxies, have similarities with material or social dimensions of deprivation, and are available in all dissemination areas (geographical areas/neighbourhoods consisting of about 400-700 individuals) [20].

The Pampalon deprivation index is based on small spatial units called dissemination areas. Each dissemination area is comprised of one or more neighbourhood blocks of houses[20]. As mentioned above, the Pampalon deprivation index is based on six census indicators that were selected because they satisfied four inclusion criteria[20]. The six census indicators,

excluding 'the proportion of single parent families,' were adjusted according to the age-sex structure of the Canadian population by direct standardization[20].

The Pampalon deprivation index has been validated. Pampalon et al. (2009) conducted a study that compared individual-level socioeconomic data with area-level socioeconomic data specifically for monitoring inequalities in health[27]. The study measured the social and material deprivation scores both for individual level and area-level (using the Pampalon deprivation index). The study examined the health indicators of life expectancy and disability-free life expectancy, and risk of mortality and disability[27]. Data were collected from Canadian Census data and death records from populations of Toronto, Montreal, Vancouver, and small rural towns[27]. The authors reported that the individual-level deprivation showed wider gaps in life expectancy and disability-free life expectancy than the area-level deprivation[27]. Nevertheless, both methods of measurements (individual-level or area-level) of deprivation showed an association with inequalities in mortality and disability[27]. Area-level socioeconomic indicators are useful in investigating inequalities in health and are capable of detecting inequalities in health in a significant, consistent and reliable manner in urban and rural geographical areas[27].

Moreover, it is unfortunate that socioeconomic status variables are missing from EMR. However, deprivation indices can be used as a proxy for individual-level socioeconomic status. The Pampalon deprivation index may be committing an ecological fallacy where areal-level characteristics are used as a proxy for individual-level characteristics. This limitation is moderated by the fact that health outcomes are not driven solely by individual-level characteristics; community level characteristics and family also impacts health of an individual[43]. Therefore, deprivation indices can be used (a) as a simple method to proxy

individual-level socioeconomic variables that are missing from EMR, and (b) as a means to understand the role of neighbourhood level variables in health outcomes.

2.7 Electronic Medical Records Data

The data necessary for this proposed study will be collected from electronic medical records (EMR). There are many advantages and disadvantages to this type of data.

Unlike other countries such the Netherlands and UK, the adoption of EMR among primary healthcare providers in Canada had been slow[22]. However, their use is expected to increase across Canada since they offer an opportunity for health practices to measure success in reaching their targets and allow collected information to be used for research[22]. EMRs are not primarily structured to be an information source for research and there are multiple EMR systems currently being used across Canada with varying methods on data entry and extraction[19]. This makes it challenging to extract data for the purpose of research. Also, it stands to reason that high quality EMR data is essential for producing high quality, valid research results[23]. It is true that the quality of the EMR data maybe limited due to missing data, inaccurate data entry and lack of standardized medical terminology in some parts of the EMR[23]. However, for chronic disease management, EMR data is very robust and in many respects more comprehensive and reliable than hospital discharge databases, disease specific registries and national health surveys[24].

Table 1 compares EMR data to healthcare Billing data. Administrative data is gathered from administering healthcare services, enrolling patients into health insurance plans, and reimbursing healthcare providers for services[31]. Administrative data includes EMR and billing

data[32]. In the literature however, the term *administrative data* is used to describe databases that are primarily for billing purposes and the term EMR data is used to describe clinical databases in primary healthcare. Billing data are readily accessible and encompass most of the population, but they lack detailed clinical information, such as blood pressure and blood cholesterol measurements[32]. On the other hand, EMRs captures detailed longitudinal information, such as smoking status and clinical and laboratory measurements, on individual patients that are not found from other sources [32].

Table 1: Comparison of electronic medical records (EMR) and billing data

	EMR	Billing data
EMR is superior to Billing data	Records specific health measures	Limited or no health measures recorded
	Primarily used for the purposes of clinical care	Primarily used for the purposes of billing
EMR is inferior to Billing data	Only a subset of patients have EMR	Virtually captures entire Canadian population
	Used only in primary care	Used in hospitals, clinics, and other health centres

The Canadian Primary Care Sentinel Surveillance Network (CPCSSN) offers a unique opportunity to investigate many common chronic diseases[24]. CPCSSN is an electronic medical record-based information system specifically created for the surveillance of chronic disease in primary healthcare settings[24]. CPCSSN consists of 10 Primary Care Research Networks (PCRN) across Canada. One of which (Centre for Studies in Primary Care (CSPC)) is based in Kingston, Ontario. CPCSSN gathers information from EMRs across the country related to diabetes, hypertension, depression, osteoarthritis, chronic obstructive lung disease and three

neurological diseases (dementia, epilepsy and Parkinson's disease). The extracted data are categorised into the following: network and provider identifiers, de-identified patient demographics, encounter data, health condition, physical examination, risk factors, referrals, laboratory tests, procedures and medications[24]. With regards to this proposed study, the CPCSSN database was an ideal primary source of data since it captured all health outcomes of interest related to diabetes (haemoglobin A1c and LDL levels for example). In addition, early studies of validity show that CPCSSN algorithm for diabetes has a sensitivity of 100% and a specificity of 99% [36]. The CPCSSN algorithm for diabetes is unique to CPCSSN[36].

Chapter 3: Methods

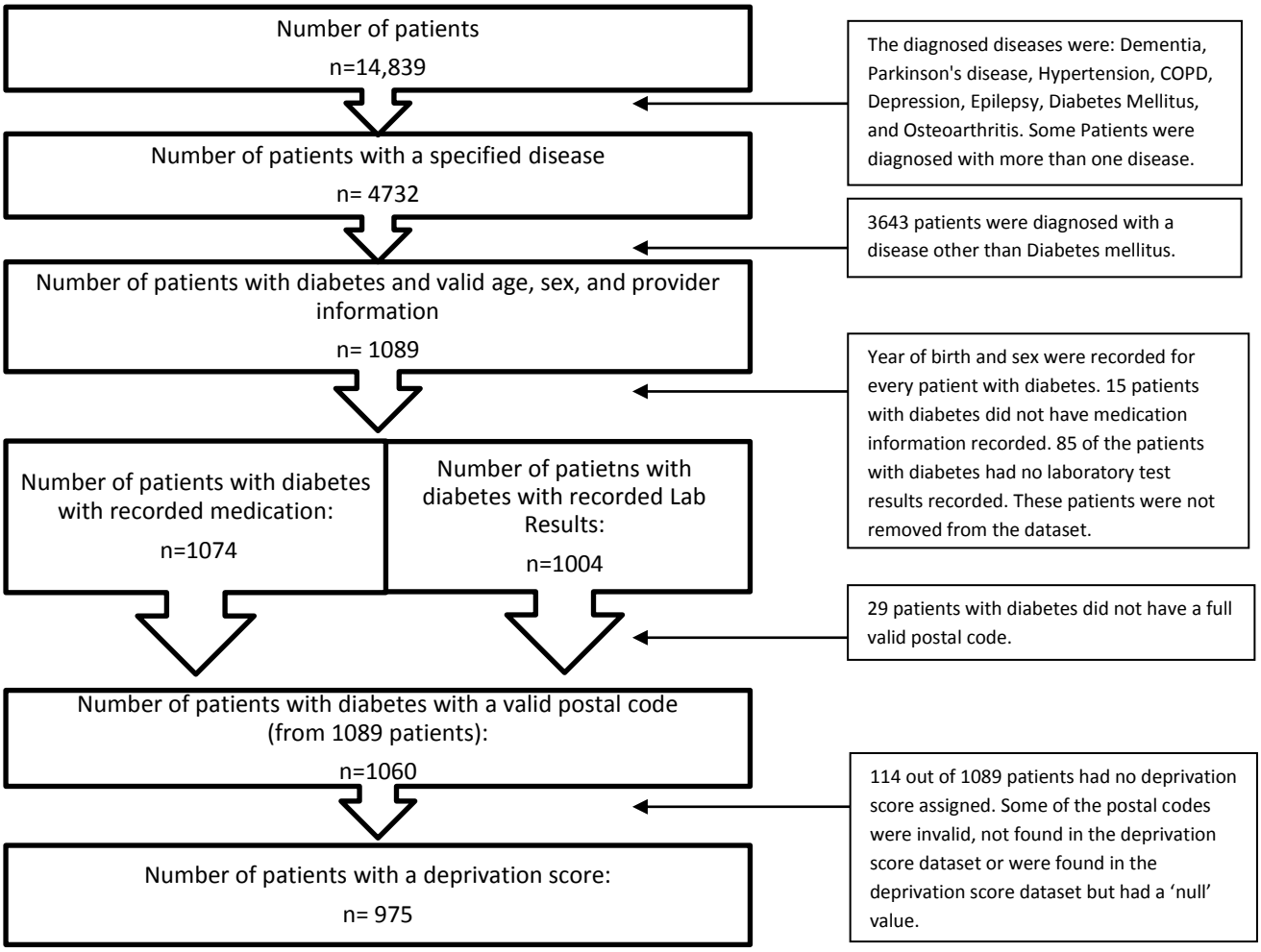
3.1 Study Design

This study used a cross-sectional design to investigate the quality of primary care and deprivation of patients with diabetes in Southeastern Ontario.

3.2.1 Study Population

The population sample was comprised of persons aged 18 years and over with a CPCSSN diagnosis of diabetes mellitus who attended an academic multiprofessional primary care practice in Kingston during the period of July 1st, 2011 to June 30th, 2012. There was no distinction made between type 1 and type 2 diabetes mellitus. Ultimately, 1089 patients with diabetes were identified and of those patients 975 had deprivation scores (see Figure 2). All analyses were completed using the 975 patients with diabetes and a valid postal code.

Figure 2. Data merging process



3.2.2 Exclusion Criteria

Persons were excluded from the final sample if they had no valid postal code or no calculated deprivation score. Persons were not excluded if they were missing laboratory test results or prescription medications records.

3.2.3 Data Sources

Electronic medical records, demographics, deprivation scores and postal codes were obtained from different sources. Demographic and clinical information on all patients and their providers at the clinical practice were obtained from a database maintained by Canadian Primary Care Sentinel Surveillance Network (CPCSSN). Patient postal codes were obtained from a database maintained by the clinical practice itself. A postal code conversion file, which combined postal codes with deprivation scores, was obtained from Statistics Canada. Even though the data extracted from the clinic covered the duration of treatment of each patient, the data used for analysis was limited to data collected between July 1, 2011 and June 30, 2012; a total of twelve months of observations. The data was limited to 12 months of observation since the quality of care indicators, such as low density lipoproteins and haemoglobin A1c, were suggested by the Canadian Diabetes Association to be measured within a 12-month period.

3.3 Description of Main Measures

3.3.1 Diabetes

Patients with diabetes mellitus were identified by a unique CPCSSN algorithm, which was based on various disease indicators, including: billing data (code 250.X), laboratory test results (hemoglobin A1c >0.07 and fasting blood sugar >7 mmol/litre), and medications prescribed (insulin, glyburide, and metformin) [36]. The diagnostic algorithm for diabetes mellitus has been shown to be accurate with a sensitivity of 100%[36].

3.3.2 Quality of Primary Care Indicators

Nine quality of care indicators were included: low-density lipoproteins (LDL), albumin creatinine ratio (ACR), haemoglobin A1c, blood pressure, and prescription of angiotensin converting enzyme (ACE) inhibitors or angiotensin II receptor antagonists (ARBs). For each of LDL, ACR, haemoglobin A1c, and blood pressure two variables were created: (1) if they were recorded into the patients' electronic charts within 12 months (July 1, 2011 to June 30, 2012) and (2) if the results were 'on target' or 'above/below target'. The variables had two levels of coding: '0' and '1'. For the first set of variables, if there was a recorded value, then '1' was given; otherwise '0' was given. For the second set of variables, if the recorded value was 'on target' (within the suggested normal range), then '1' was given; otherwise '0' was given. For example, blood pressure was categorized into 'recorded' or 'not recorded' and then the recorded values were further categorized into 'on target' if the patient's blood pressure was <130/80 mmHg or 'above target' if the blood pressure was $\geq$130/80 mmHg. When the blood pressure was recorded in patients' electronic charts, a code of '1' was given; a code of '0' was given when blood pressure was not recorded in the chart. Furthermore, a code of '1' was given when blood pressure was 'on target'; a code of '0' was given when blood pressure was 'above target.' When patients had more than one recording for a measure, only the most recent recording was considered. As for the prescribed medication of ACE or ARBs, one variable was created to identify if a patient was prescribed an ACE or ARBs. If a patient was prescribed any ACE or ARBs, then a code of '1' was given; otherwise '0' was given.

3.3.3 Measuring Deprivation

A dataset including postal codes of Southeastern Ontario linked with deprivation scores was obtained from Statistics Canada. The derivation scores were derived in the following manner. The Pampalon deprivation index was based on 'spatial units' or dissemination areas. Each dissemination area was an area comprised of neighbourhood blocks (400-700 persons) [20]. Dissemination areas are referred to as neighbourhoods in this study for clarity purposes. Since the index was intended as a proxy for individual measures, small neighbourhoods were preferred to improve the homogeneity of the socioeconomic status given to each individual in a neighbourhood. All neighbourhoods in Southeastern Ontario were identified, and then six census socioeconomic indicators were applied to each neighbourhood. Three of the six census indicators apply to material deprivation: (a) proportion of persons who have no high school diploma, (b) employment to population ratio, and (c) the average income of persons aged 15 and over. The other three census indicators apply to social deprivation: (a) proportion of persons aged 15 and over who are separated, divorced or widowed, (b) proportion of persons living alone, and (c) the proportion of single-parent families[20]. Each neighbourhood was attributed a score reflecting its socioeconomic status; this score was a combination of the material and social deprivation for each neighbourhood in Southeastern Ontario[20].

Neighbourhoods were grouped together and then ranked from least to most deprived, for both material and social deprivation. The ranked neighbourhoods were then divided into quintiles, each quintile representing 20% of Southeastern Ontario's population. Quintile 1 represented the least deprived and quintile 5 represented the most deprived.

Subsequently, each of the 975 patients in the study was mapped to these deprivation quintiles using the Statistics Canada Postal Code Conversion File. The Postal Code Conversion File provides the link between the postal codes of the individual patients and the standard 2006 Census geographical areas and in turn to the deprivation scores. The Postal Code Conversion File was available at no cost through the Statistics Canada website[25].

3.4 Data Management

All datasets were merged together to create one complete dataset of exposures, outcomes, and covariates (Appendix 4). First, the crude number of patients in the clinical practice was identified. Next, the number of patients who were diagnosed with a specific disease was identified and from these patients, the number of patients who were diagnosed specifically with diabetes mellitus was identified (1089 patients). The datasets of patient demographics were merged with the list of 1089 patients with diabetes to include patients' age and sex. The providers' age and sex information was also merged to identify to which provider each patient with diabetes belonged. Therefore, all patients with diabetes had complete information about their age, sex and provider. Next, the datasets of laboratory test results and medication were merged with the previously created dataset of 1089 patients with diabetes. The laboratory test results and prescribed medication not in the time period between July 1, 2011 and June 30, 2012 were excluded. Laboratory test results that were not measures of LDL, blood pressure, haemoglobin A1c or ACR were removed and all units of measurements were standardized. All prescribed medications that were not ACE inhibitors or ARBs were removed as

well. Next, patients with diabetes were assigned deprivation scores, and for this, postal codes were necessary.

The dataset that contained the patient's age and sex, provider, medication and laboratory test results was merged with the dataset that contained the patients' postal codes. Not all patients had valid postal codes. Some of the patients with diabetes had invalid postal codes because the codes were either not recorded or were incomplete. In addition, some postal codes were entered incorrectly by having a bracket after the first letter of the postal code (e.g. K)H 6Y3); the letter "O" entered instead of the number zero; three letters as the first part (e.g. KTR 5S1); three numbers as the second part (e.g. K6T 872).

Finally, when the deprivation score dataset was linked with the patients' medical information and postal codes dataset, 114 patients had no deprivation score assigned. Twenty-eight of these patients had an invalid postal code so the dataset with deprivation scores could not be linked. Other patients who had a postal code recorded did not have a deprivation score calculated for a variety of reasons: their postal codes were from outside Southeast Ontario; were from Southeast Ontario but were not listed in the deprivation score dataset; or were found in the deprivation score dataset but had a null value for all measures of deprivation.

To verify the data was processed properly, this entire process of merging the datasets was repeated in reverse order (i.e. identifying the patients with diabetes with the correct postal codes and valid deprivation scores first) yielding the same numbers as in the original processing steps (Appendix 5). Also, the file merging process was reviewed by a CPCSSN data manager.

3.5 Data Analysis

The primary comparison of interest was to compare the quality of care indicators of patients with diabetes from least and most deprived neighbourhoods. This was accomplished using generalized estimating equations (GEE) due to the inherent clustering of patients within each physician. Using GEE, the proportion of patients achieving each outcome of interest was estimated for each deprivation quintile. Relative risks were estimated for each quintile in comparison to those least deprived. The GEE model also allowed for other important covariates, such as patient age, sex, and comorbidity to be accounted for in the analysis. The comparison of secondary interest was to compare the same quality of care indicators between males and females with diabetes, using the same analytic approach.

For this investigation, age was treated as a continuous variable since specific age groups were not of interest. Also, from the CPCSSN electronic medical records, patients with diabetes that have a comorbid diagnosis of hypertension were identified. However, other important diabetes comorbid conditions and complications such as blindness, end-stage renal failure, and other vascular diseases were not readily available from that data at this time and were, therefore, not included in the study. Moreover, age, sex and hypertension were tested as potential effect modifiers first. Interaction terms were created of the main exposure variable and the variable suspected of being an effect modifier; a variable was determined to be an effect modifier if it was significant (p-value < 0.05). If age, sex and hypertension were not found to be effect modifiers, then they were tested as potential confounders using the backward

deletion approach according to change in estimate criteria. Variables were removed when total change from the adjusted model for all factors was less than 5%.

Furthermore, to address the issue of missing data, individuals with missing data were compared to individuals without missing data on key variables that were not missing from the dataset. This may inform sources of potential bias if systematic differences were observed[26]. If there were no notable differences between individuals with the missing data and individuals without the missing data, then that data was assumed to be missing at random.

All data management and analyses were done using Statistics Analysis Software (SAS) version 9.3[52]. Lists of all the outcomes, exposures, confounders and effect modifiers are provided in Appendix 6.

3.5.1 Generalized Estimated Equations for Modeling Data:

Generalized estimated equations (GEE) provide a method for modelling binary outcome data, accounting for clustering within the data without requiring additional terms in the model[47]. This is done by assuming that the data are correlated within clusters and that correlation is estimated from the data during the estimation process[47]. However, it is important to note that the coefficients arising from GEE are the population-averaged effects and the results should be interpreted accordingly[47]. The GEE method estimates the average response over the population rather than estimated effect for a given individual[48]. The population-averaged interpretation of the coefficients offered by the GEE approach was one of the reasons this method was chosen as this interpretation was deemed most appropriate to address the objectives of the study.

Simple unadjusted models were created for each of the 9 quality of care indicators; adjusted models (with the covariates) were developed subsequently. The reference group for the exposure was selected to be the 1st quintile (least deprived), which was contrasted with the 5th quintile to test if the difference between the two parameters was equal to zero. In the model statement, binomial distribution was selected because the outcomes were binary. Exchangeable correlation type was selected to account for the clustering of patients within physicians; this type assumes that correlation between observations was the same across all clusters. The Link Function was set as 'log' so that estimated coefficients would be log relative risks rather that log odds ratios. All models converged except for models assessing prescribed medication. In this case, the estimates were approximated using a Poisson model with robust error variance[38].

3.6 Ethics

Ethics approval was received from Research Ethics Board at Queen's University (Appendix 7). Before submission of the ethics application, one particular issue of re-identification of patients during data linkage was recognized. To reduce this risk of the re-identification of an individual, the patient's electronic medical record data and postal code were not present together during any point of data linkage. Only the patient's anonymized ID number was used to obtain his/her postal code, and then the postal code were linked to the specific deprivation area and, therefore, a deprivation score. During the data analysis, the patient's ID, health information and deprivation score was used; no postal code were necessary.

Chapter 4: Results

4.1 Descriptive Results

4.1.1 Patient Characteristics

Of the total 975 patients diagnosed with diabetes mellitus, 494 (51%) were females with an average age of 63 years, and 481 (49%) were males with an average age of 62 years. Figure 3 illustrates the age distribution of the sample population for females and males.

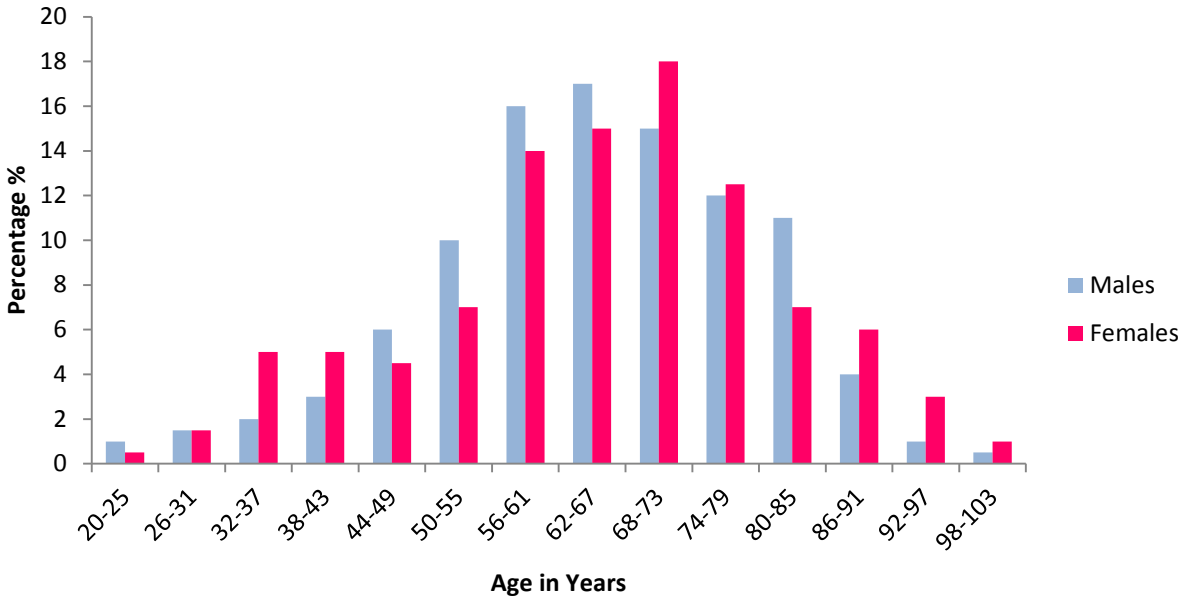


Figure 3: Age distribution of males and females with diabetes mellitus

4.1.2 Provider Characteristics

In total, there were 23 providers (family physicians) in the clinic, but 21 of the providers gave care to the current patients with diabetes. The mean and median age of providers was 55 years of age. There were 11 male providers and 10 female providers. The average number of patients with diabetes under a provider's care was 46 patients.

4.1.3 Comorbidities

975 patients were diagnosed with diabetes mellitus. Some of these patients with diabetes had other chronic diseases, such as: chronic obstructive pulmonary disease (COPD), dementia, depression, epilepsy, hypertension, osteoarthritis and Parkinson's disease. These 7 comorbid conditions are the conditions for which CPCSSN has developed case definitions. Undoubtedly, patients will have other comorbid conditions beyond these 7, however, as developing further case definitions was outside the scope of this work the analysis was limited to these 7 conditions. For example, some patients were diagnosed with depression, diabetes mellitus, hypertension and osteoarthritis. 335 (34 %) of patients with diabetes were diagnosed with diabetes only. 398 (41%) were diagnosed with one other chronic condition in addition to diabetes. 184 (19%) of patients with diabetes were diagnosed with two other chronic conditions in addition to diabetes. 49 (5%) were diagnosed with three other chronic conditions in addition to diabetes. 9 (1%) were diagnosed with four other chronic conditions in addition to diabetes. Specifically, 47% of the patients with diabetes were also diagnosed with hypertension which was the most frequent comorbidity. Therefore, hypertension was selected as an

indicator of comorbidity. Depression and osteoarthritis follow at 21% and 17% respectively. Figure 4 illustrates the proportion of other comorbidities in addition to diabetes mellitus.

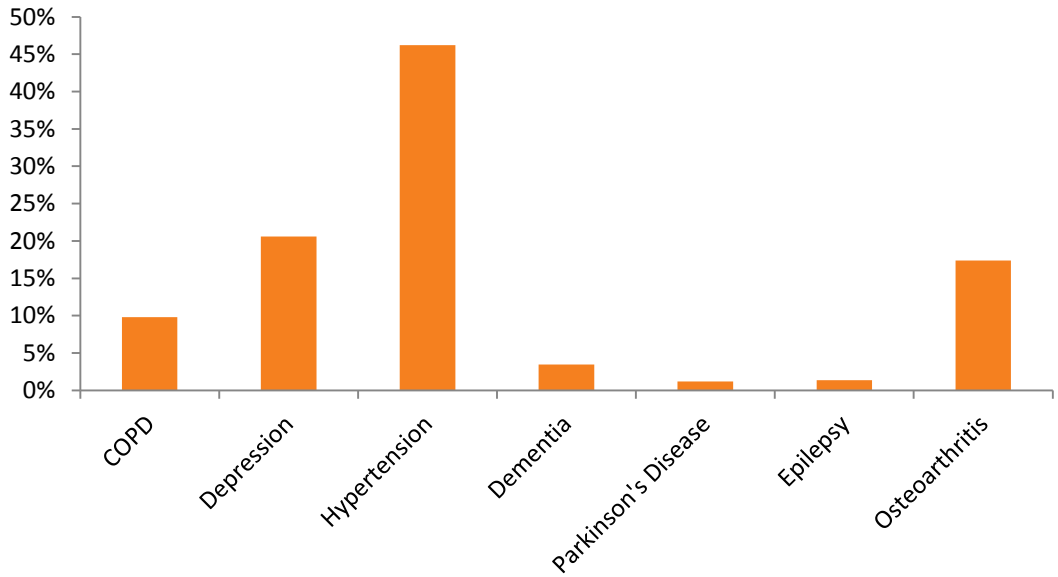


Figure 4: Proportion of patients with diabetes who are diagnosed with other chronic diseases

4.1.4 Quality of Care Indicators

Quality of care indicators included the following: laboratory test results (low-density lipoproteins, albumin creatinine ratio, and haemoglobin A1c), measures taken during clinical visits (blood pressure), and prescribed medications (angiotensin converting enzyme inhibitors and angiotensin II receptor antagonists). There were 85 (8%) patients with diabetes who had no laboratory test results recorded. Of these 85 patients, 42 were female with an average age of 53 years, and 43 were male with an average age of 50 years. Of all the 975 patients with diabetes, 585 (60%) patients had their low density lipoproteins (LDL) measured within 12 months and only 48% of those patients were within the suggested target range. Only 334 (34%)

patients had their albumin creatinine ratio measured within 12 months; 56% of those patients were within target range. As for blood sugar control, 697 (71%) patients had their haemoglobin A1c measured within 12 months; 46% of those patients were within target range. The majority of patients with diabetes, 854 (88%) patients, had their blood pressure measured within 12 months; 37% of those patients were within the target range. Finally, 688 (71%) were on angiotensin converting enzyme (ACE) inhibitors and angiotensin II receptor antagonists (ARBs) prescribed medication.

When comparing males to females, more males were on target with their LDL (35% vs. 23%, $p<0.001$), had their ACR recorded (40% vs. 29%, $p<0.001$), and were prescribed ACE inhibitors or ARBs (76% vs. 65%, $p<0.001$). On the other hand, more females were on target with their haemoglobin A1c (36% vs. 29%, $p=0.018$). Table 2 is the distribution of quality of care indicators by gender.

Table 2: Quality of care Indicators (patients with diabetes , n=975)	Total	Female (n=494)	Male (n=481)	P-value
Low-Density Lipoproteins				
Recorded	585 (60.0%)	289 (58.5%)	296 (61.5%)	0.3332
Not Recorded	390 (40.0%)	205 (41.5%)	185 (38.5%)	
Low-Density Lipoproteins				
On Target (≤2.0 mmol/L)	282 (48.2%)	115 (23.3%)	167 (34.7%)	**0.0001**
Above Target (>2.0 mmol/L)	303 (51.8%)	174 (35.2%)	129 (26.8%)	
Hemoglobin A1c				
Recorded	697 (71.5%)	352 (71.3%)	345 (71.7%)	0.8708
Not Recorded	278 (28.5%)	142 (28.7%)	136 (28.3%)	
Hemoglobin A1c				
On Target (≤7.0%)	319 (45.8%)	179 (36.2%)	140 (29.1%)	**0.0177**
Above Target (>7.0%)	378 (54.2%)	173 (35.0%)	205 (42.6%)	
Albumin Creatinine Ratio				
Recorded	334 (34.3%)	144 (29.1%)	190 (39.5%)	**0.0007**
Not Recorded	641 (65.7%)	350 (70.8%)	291 (60.5%)	
Albumin Creatinine Ratio				
On Target[1]	187 (56.0%)	91 (18.4%)	96 (20.0%)	0.5421
Below Target	147 (44.0%)	53 (10.7%)	94 (19.5%)	
Blood Pressure				
Recorded	853 (87.5%)	436 (88.3%)	417 (86.7%)	0.4603
Not Recorded	122 (12.5%)	58 (11.7%)	64 (13.3%)	
Blood Pressure				
On Target (<130/80 mmHg)	316 (37.0%)	153 (30.8%)	163 (33.9%)	0.3307
Above Target (≥130/80 mmHg)	537 (63.0%)	283 (57.3%)	254 (52.8%)	
ACE-ARB[2]				
Prescribed	688 (70.6%)	322 (65.2%)	366 (76.1%)	**0.0002**
Not Prescribed	287 (29.4%)	172 (34.8%)	115 (23.9%)	

[1] ACR On Target: Female <2.8 mg/mmol, Male <2.0 mg/mmol)

2 Angiotensin Converting Enzyme Inhibitor, Angiotensin Receptor Blockers

4.1.5 Deprivation Quintiles

The combined material and social deprivation score was previously calculated using the Pampalon deprivation index for each neighborhood; the scores of the neighborhoods included in this study were available from KFL&A Health Unit[53]. Nine hundred and seventy five of the initial 1089 patients had valid deprivation scores, 114 patient postal codes had no deprivation scores assigned due to invalid postal codes or uncalculated deprivation scores. The raw combined deprivation scores of social and material deprivation ranged from -1 to 1 with an average score of 0.01. An individual with a higher score means he/she is more socially and

materially deprived than an individual with a lower score. Figure 5 illustrates the distribution of the combined social and material scores among the patients with diabetes.

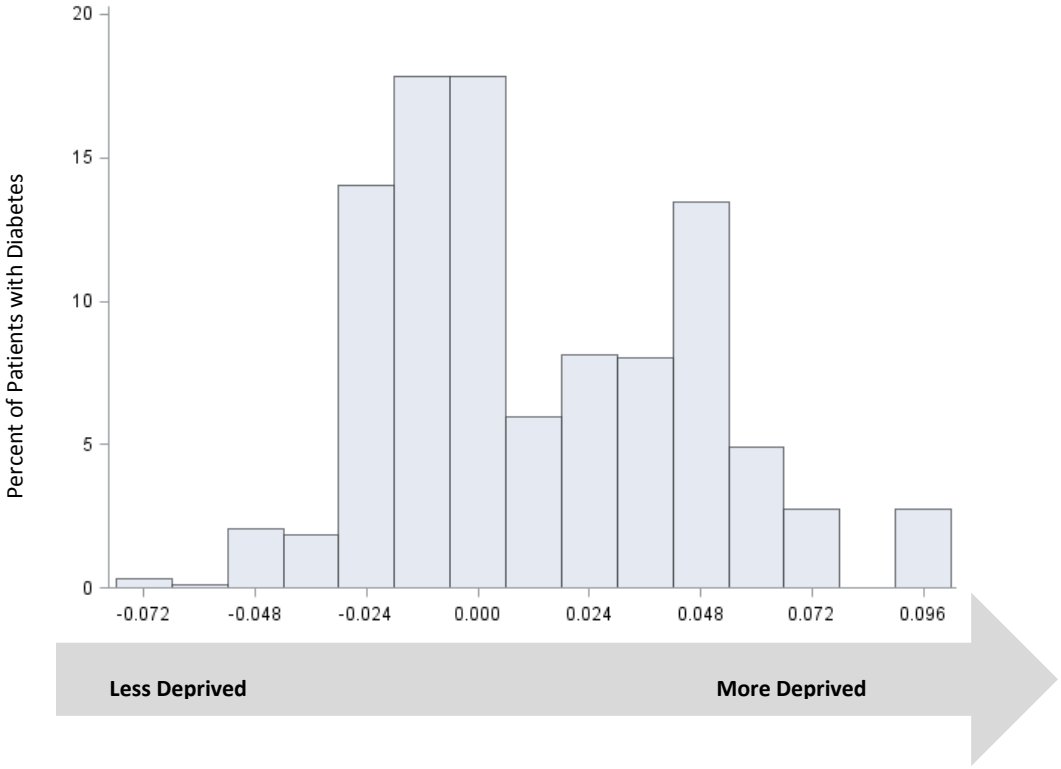


Figure 5. Raw deprivation scores of the patients with diabetes ranging from least to most socially and materially deprived

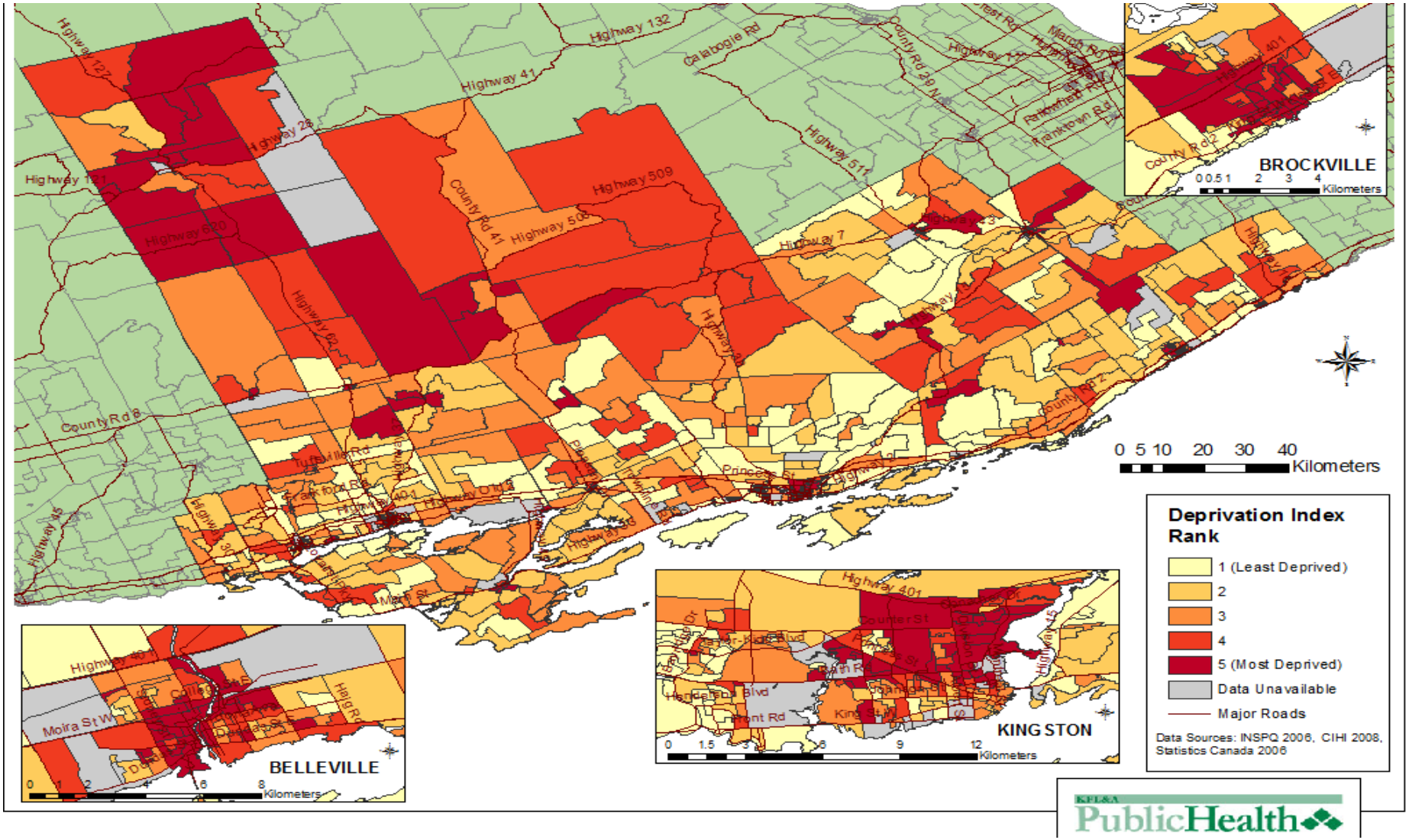
Quintiles were previously calculated so that each 20% of the Southeastern Ontario population represented a deprivation group. For example, the 20% of individuals with the lowest scores represented the least deprived group, and the 20% of patients with the highest scores represented the most deprived group. The quintile groups of the study sample of patients with diabetes were identified. Approximately 21% of the sample of patients with diabetes belonged to the least deprived group (1st quintile) in Southeastern Ontario, and

approximately 30% belonged to the most deprived (5th quintile). Table 3 shows the distribution of deprivation across the five quintiles as well as the proportion of males and females in each quintile, and Figure 6 shows these five quintiles geographically.

Table 3:Deprivation Quintiles of Patients with diabetes , (patients with diabetes, n=975)

	Total	Female (n=494)	Male (n=481)
Deprivation Quintiles			
Quintile 1 (Least Deprived)	219 (22.5%)	110 (22.2%)	109 (22.7%)
Quintile 2	183 (18.8%)	96 (19.4%)	87 (18.1%)
Quintile 3	163 (16.7%)	72 (14.6%)	91 (18.9%)
Quintile 4	119 (12.2%)	65 (13.2%)	54 (11.2%)
Quintile 5 (Most Deprived)	291 (29.9%)	151 (30.6%)	140 (29.1%)

Figure 6: Combined material and social deprivation map of the catchment area, Southeast Ontario. Adapted from INSPQ 2006, CIHI 2008, Statistics Canada 2006. Used with the permission of KFL&A Public Health.



4.2 Multivariate Results

4.2.1 Generalized Estimated Equations Modeling Results:

Comorbidities, age and sex of patients and physicians were neither effect modifiers nor confounders. Moreover, patients with diabetes who were most deprived were less likely than those least deprived to have their most recent LDL within normal range (RR=0.84; CIs 0.73-0.98; p-value=0.026). As for the rest of the quality of care indicators, although the results were not statistically significant, they show that there was no difference in management of diabetes between least and most deprived patients with diabetes, which can be considered as positive findings for the clinical practice. The following are the rest of the results in detail. Compared to least deprived patients with diabetes, those patients who are most deprived were as likely to: have their LDL recorded within 12 months (RR=0.97; CIs 0.80-1.18; p-value=0.785), have had their most recent haemoglobin A1c within normal range (RR=0.92; CIs 0.72-1.16; p-value=0.474), have had their most recent albumin creatinine ratio within normal range (RR=0.82; CIs 0.60-1.12; p-value=0.222), have had their albumin creatinine ratio recorded within 12 months (RR=0.95; CIs 0.70-1.29; p-value=0.724), and have had their most recent blood pressure within normal range (RR=0.94; CIs 0.74-1.19; p-value=0.604). Furthermore, patients with diabetes who were most deprived are as likely as those least deprived to have had their haemoglobin A1c and blood pressure recorded within 12 months (RR=1.01; CIs 0.91-1.12; p-value=0.889 and RR=0.99; CIs 0.93-1.06; p-value=0.793 respectively). Results were adjusted for patient and provider age and sex, and hypertension. Table 4 summarizes the GEE

modeling results specifically for the most deprived patients with diabetes (5th quintile) in relation to the least deprived individuals (1st quintile).

Table 4: Relative risks of most deprived patients (5th quintile) compared to least deprived patients (1st quintile) , (patients with diabetes, n=975)

	Relative Risk* (95% CI)	P-value
Low-Density Lipoproteins		
Recorded (or not)	0.97 (0.80-1.18)	0.7850
On Target (or above)	0.84 (0.73-0.98)	**0.0264**
Haemoglobin A1c		
Recorded (or not)	1.01 (0.91-1.12)	0.8890
On Target (or above)	0.92 (0.72-1.16)	0.4735
Albumin Creatinine Ratio		
Recorded (or not)	0.95 (0.70-1.29)	0.7242
On Target (or below)	0.82 (0.60-1.12)	0.2215
Blood Pressure		
Recorded (or not)	0.99 (0.93-1.06)	0.7932
On Target (or above)	0.94 (0.74-1.19)	0.6041
ACE/ARB		
Prescribed (or not)	1.08 (0.97-1.21)	0.1779

* From a GEE model adjusted for patient and provider age and sex, and hypertension. Relative Risk (RR) = (event rate in 5th quintile/event rate in 1st quintile).

Table 5 presents more detailed relative risks of each quintile in relation to the least deprived patients with diabetes.

Table 5: Relative risks of each quintile in relation to the least deprived (1st quintile), (patients with diabetes, n=975)

Quality of care indicators	Relative Risk* (95%CI)			
	Q2	Q3	Q4	Q5
Low-Density Lipoproteins				
On Target (or above)	**0.76 (0.61-0.96)**	0.84 (0.69-1.03)	0.83 (0.68-1.01)	**0.84 (0.73-0.98)**
Recorded (or not)	0.97 (0.82-1.15)	1.07 (0.88-1.31)	1.05 (0.87-1.27)	0.97 (0.80-1.18)
Haemoglobin A1c				
On Target (or above)	1.04 (0.85-1.27)	0.97 (0.77-1.22)	0.98 (0.71-1.36)	0.92 (0.72-1.16)
Recorded (or not)	0.97 (0.84-1.11)	0.98 (0.85-1.13)	1.03 (0.89-1.20)	1.01 (0.91-1.12)
Albumin Creatinine Ratio				
On Target (or below)	0.98 (0.73-1.31)	1.11 (0.86-1.44)	0.90 (0.63-1.27)	0.82 (0.60-1.12)
Recorded (or not)	0.91 (0.69-1.20)	0.99 (0.75-1.30)	0.98 (0.73-1.31)	0.95 (0.70-1.29)
Blood Pressure				
On Target (or above)	0.73 (0.52-1.03)	0.84 (0.64-1.11)	0.87 (0.63-1.20)	0.94 (0.74-1.19)
Recorded (or not)	0.96 (0.89-1.04)	0.96 (0.89-1.03)	0.99 (0.94-1.05)	0.99 (0.93-1.06)
ACE/ARB				
Prescribed (or not)	0.97 (0.86-1.10)	1.03 (0.89-1.19)	1.10 (0.96-1.25)	1.08 (0.97-1.21)

* From a GEE model adjusted for patient and provider age and sex, and hypertension.

Finally, the same methods were followed when modeling patient sex as the main exposure. The same methods were applied to assess possible effect modifiers and confounders as well. There were a few statistically significant results that will be discussed further in the discussion section. Compared to male patients with diabetes, female patients with diabetes were less likely to: have had their most recent low-density lipoproteins within normal range (RR=0.71; CIs 0.62-0.81; p-value <0.001), have had their albumin creatinine ratio recorded within 12 months (RR=0.75; CIs 0.61-0.92; p-value=0.006) and be prescribed ACE inhibitors or ARBs medications (RR=0.79; CIs 0.69-0.90; p-value <0.001). However, female patients with diabetes were more likely than male patients with diabetes to have their most recent haemoglobin A1c within normal range (RR=1.24; CIs 1.10-1.40; p-value <0.001) and have had their most recent albumin creatinine ratio within normal range (RR=1.25; CIs 1.05-1.50; p-value=0.015). The rest of the results were not statistically significant and were interpreted as follows: female patients with diabetes were as likely as male patients with diabetes to have their low density lipoproteins recorded within 12 months (RR=0.97; CIs 0.85-1.10; p-

value=0.601), and to have had their most recent blood pressure within normal range (RR=0.90; CIs 0.80-1.02; p-value=0.091). Furthermore, compared to male patients with diabetes, females patients with diabetes were as likely to have had their haemoglobin A1c recorded within 12 months and have had their blood pressure recorded within 12 months (RR=0.99; CIs 0.90-1.10; p-value=0.911 and RR=1.02; CIs 0.97-1.07; p-value=0.455 respectively). Table 6 summarizes the GEE modeling results of female patients with diabetes compared to male patients with diabetes.

Table 6: Relative risks of female patients with diabetes , (patients with diabetes, n=975)

	Relative Risk* (95%CI)	P-value
Low-Density Lipoproteins		
Recorded (or not)	0.97 (0.85-1.10)	0.6059
On Target (or above)	0.71 (0.62-0.81)	**<0.0001**
Haemoglobin A1c		
Recorded (or not)	0.99 (0.70-1.10)	0.9114
On Target (or above)	1.24 (1.10-1.40)	**0.0005**
Albumin Creatinine Ratio		
Recorded (or not)	0.75 (0.61-0.92)	**0.0057**
On Target (or below)	1.25 (1.05-1.50)	**0.0146**
Blood Pressure		
Recorded (or not)	1.02 (0.97-1.07)	0.4554
On Target (or above)	0.90 (0.80-1.02)	0.0906
ACE/ARB		
Prescribed (or not)	0.79 (0.69-0.90)	**0.0006**

* From a GEE model adjusted for patient age, provider age and sex, hypertension, deprivation.
Relative Risk = (event rate in Females/event rate in Males)

Chapter 5: Discussion

5.1 Summary of Main Findings

This study examined the material and social deprivation and quality of care in 975 patients with diabetes attending a primary care practice in Kingston from 2011 to 2012. There were four main findings.

First, a substantial number of patients with diabetes were also diagnosed with other chronic conditions, the most common of which was hypertension. Second, the majority of the patients with diabetes belonged to both the most deprived quintile and the least deprived quintile with similar proportions of males and females in both quintiles. Third, this study found variation in the extent that quality of primary care indicators were recorded. The most common recorded laboratory test was blood pressure (87%), while the least recorded was albumin creatinine ratio (34%). In general, half of the patients with diabetes missed their targets on important indicators, such as low-density lipoproteins (48%), hemaglobin A1c (54%), albumin creatinine ratio (44%), and blood pressure (63%). Fourth, the study found that patients with diabetes who were from deprived neighbourhoods were less likely to have had their low-density lipoproteins controlled (RR= 0.84; CIs 0.73-0.98). Furthermore, women with diabetes were less likely than men with diabetes to have had their low-density lipoproteins under control. Women with diabetes were also less likely than men with diabetes to be prescribed ACE inhibitors or ARBs (RR= 0.79; CIs 0.69-0.90). However, women with diabetes were more likely than men with diabetes to have had their most recent haemoglobin A1c within normal

range (RR= 1.24; CIs 1.10-1.40) and have had their most recent albumin creatinine ratio within normal range (RR= 1.25; CIs 1.05-1.50).

5.2 Interpretation of Findings

This study found that prevalence of diabetes was 7%, which is consistent with reported estimates of diabetes in Canada[4,7]. The population sample had a relatively equal proportion of males to females. There was little difference in average age and age distribution of males and females. Due to these similarities between the males and females, no systematic error of sampling bias was introduced. Moreover, a very large number of patients with diabetes were diagnosed with hypertension. This was anticipated since cardiovascular diseases are the leading cause of mortality in patients with diabetes; hypertension occurs four times more often in individuals diagnosed with diabetes compared with individuals without diabetes[6,46].

Overall, deprivation did not appear to affect how the patients with diabetes were treated. Belonging to either a very materially and socially deprived neighbourhood or a very materially and socially privileged neighbourhood does not affect the glucose control, blood pressure, or type of medication prescribed of patients with diabetes. Nevertheless, level of deprivation may affect blood cholesterol control; patients with diabetes from less privileged neighbourhoods are less likely to have their blood cholesterol at the suggested normal range. Blood cholesterol can be controlled through a prescribed medication, balanced nutrition and an active lifestyle. Since there was no difference in prescribed medication across the deprivation gradient, affording nutritious meals and engaging in physical activities may be more difficult for individuals from less privileged neighbourhoods[44]. Some studies had found more differences in

diabetes management between least and most deprived patients with diabetes. One study had found difference in achieving suggested normal targets of haemoglobin A1c and blood pressure among deprived neighbourhoods[33]. Compared to patients with diabetes living in less deprived neighbourhoods, patients with diabetes living in more deprived neighbourhoods were less likely to be on target with their blood pressure and haemoglobin A1c[33].

The quality of care indicators varied in their recording frequency. A large number of the patients with diabetes did not have any of their low-density lipoproteins (LDL), albumin creatinine ratio (ACR) and haemoglobin A1c measured. This can be attributed to the possibility that laboratory results may have been done but not entered into the patients' electronic medical charts. Also, the laboratory tests may have been requested by the patient's provider but the patient did not complete the tests or the patient did complete the tests but after 14 months for example, and subsequently not captured in this study since the data covered only a 12 month time period. Another possibility was that the laboratory test requisition was never requested in the 12 months because the patients did not visit the clinic for an opportunity to receive laboratory requisitions. Patients with no recorded LDL, ACR, and haemoglobin A1c had similar proportions of males to females and average age. The proportion of males to females was similar for patients with diabetes with laboratory results and without laboratory results, however, the average age of the two groups was different.

Blood pressure was most commonly recorded. It is strongly recommended by the Canadian Diabetes Association that patients with diabetes have their blood pressure measured at every clinical visit. However, a very large number of patients with diabetes (63%) were not in

the target range, and more females with diabetes were not on target than males with diabetes. This can be attributed to the fact that most of the patients with diabetes were also diagnosed with hypertension, but also suggests that patients with diabetes are having a difficult time in controlling their blood pressure. Lowering blood pressure is often difficult in practice[45].

Haemoglobin A1c and LDL reflect the state of disease and risk factor control. There were no large differences in the proportion of males to females with their recorded haemoglobin A1c and LDL. However, about 10% more males than females were in control with their cholesterol levels. This could be attributed to the fact that males are suspected to be at a higher risk of cardiovascular disease and, therefore, are prescribed medication to reduce the risk and control LDL levels; 76% of males with diabetes are prescribed ACE inhibitors or ARBs compared to 65% of females with diabetes. In contrast, when considering blood glucose control, 7% more females than males were on target. Blood glucose can be controlled with either lifestyle management or medication; women with diabetes may be prescribed more medication to control blood glucose or are able to have a balanced diet.

ACR were least recorded of the laboratory tests with fewer females than males had results recorded. ACR is measured in patients with diabetes to assess risk of chronic kidney disease. Although, chronic kidney disease (CKD) is one of the most common complications of diabetes, it is recommended by the Canadian Diabetes Association that patients with diabetes be screened annually[4]. Since the study period was 12 months, some patients may have taken longer than one year to test their ACR and, therefore, were not represented in the data. Another reason maybe that only patients with diabetes with a suspected high risk of CKD were

requested to have their kidney function tested. Nonetheless, most patients with diabetes were on target with their ACR measurement, but since only a small number of patients with diabetes had their ACR results recorded, the results may belong to patients who are followed up more closely. More males were below suggested normal ACR target. This also can explain that more males are being tested for ACR than females since more males were below suggested target. According to the Center for Disease Control and Prevention however, CKD is more common in females than males[39].

More males with diabetes than females with diabetes were prescribed ACE inhibitors or ARBs. This may be explained by the fact that there were more males below suggested ACR target and, therefore, males require ACE or ARB as a treatment. Also, ACE inhibitors and ARBs are prescribed routinely to individuals with coronary heart disease and heart failure, and since males are at a larger risk of cardiovascular diseases, they would be prescribed more to males than females.

On another note, none of the assessed confounders and effect modifiers, such as patient age and sex, provider age and sex were strongly relevant to the relationship of deprivation or the sex of the patients and the many outcomes. Finally, correlation between clusters was less than 2.5% for all quality of primary care indicators. This suggests that patients with diabetes on the whole were similar to each other regardless of the provider they belonged to. The correlation found in this study is less than that found in other studies such that of Sigfrid and colleagues which assessed health equity through diabetes management in primary care and the influence of deprivation[50]. The reason for this can be found in some of the limitations

of this study. One limitation for example was the small sample size and, therefore, the lack of power to detect potential difference in management of diabetes between the least and most deprived patients with diabetes.

5.3 Strengths and Limitations

This is the first Canadian study to assess the effect of deprivation on diabetes management using high quality, electronic medical record-based information system such as the Canadian Primary Care Sentinel Surveillance Network (CPCSSN). Using CPCSSN data permitted the assessment of quality of care indicators that are not currently available from any other source. Further, as this data is directly related to patients care, the quality of the data is high. This is further evident by the fact that the CPCSSN algorithm for identifying patients with diabetes is nearly perfectly sensitive and specific[36].

Another strength of this study is the analysis method used. Generalized estimating equations (GEE) are ideal when modeling data such as data in this study. GEE models provide population average estimates while requiring fewer assumptions than generalized linear mixed models when dealing with correlated data. Also, the parameter estimates are consistent whether or not correlation has been modeled correctly.

Moreover, there are limitations that need to be considered in this study. These limitations relate to the: a) ecological fallacy; b) sample size; c) deprivation scores; d) validity and completeness of the measures used; and e) generalizability of the findings. Each of these will be addressed in turn.

One limitation was the nature of some of the data collected. Since the deprivation score was collected at the area-level, an ecological fallacy is possible because area-level characteristics are used as a proxy for individual-level characteristics; not all persons living in a deprived neighbourhood may be deprived. This limitation is less of an issue when considering that health is not driven solely by individual-level characteristics. Community-level characteristics and family also impact an individual's health. Deprivation scores can be used as a simple method to proxy individual-level socioeconomic variables that are missing from electronic medical records and can be used as a mean to understand the role of neighbourhood-level variables on individual health outcomes.

The final sample size available was smaller than anticipated. The sample size needed was 2325 patients with diabetes to be able to detect a 10% difference in diabetes management between least and most deprived groups. Three clinics in Southeast Ontario were sought at the beginning of the study, but only data of patients from one clinic was available for analysis. The other prospective clinics had only partial postal codes of patients available and including them in the study required having the clinics cooperation in providing full postal codes, but that was not possible at the time. The lack of significant findings in this study may be partially attributed to lack of power to detect differences if they existed. Nonetheless, there were some significant results reported in this study.

Another limitation is related to the data used to calculate the deprivation scores. The 2006 Canadian census data was used to calculate the deprivation scores based on the Pampalon index in this study because the use of the 2011 Canadian Census data has not yet

been validated. Only the 2006 Canadian Census data has been validated and available. This is a limitation because it is not known for certain whether the measure of deprivation still applies to a given postal code. Also the Census data itself may be different for some of the patients with diabetes since the 2006 Census, which may change their deprivation score. However, the average age of the patients with diabetes in this study was about 63 years and individuals of this age group are least likely to relocate their address[41]. Also, some of the Census indicators, such as having a high school diploma, that are used to calculate the deprivation score is not likely to change for this age group.

The results of this study may be limited by the validity and completeness of the variables. Although the CPCSSN electronic medical records were ideal for this study, some potentially important variables were not collected in patients' records. Additional variables that have the potential to confound the main relationships include: a) diabetes related comorbidities like blindness, end-stage renal failure, and coronary artery disease; b) quality of care indicators like body mass index, neuropathy or foot examinations, nutrition, physical activity, blood glucose self-monitoring, smoking status, whether smokers were offered the smoke cessation program; c) socioeconomic status indicators like income, level of education, and marital status; and d) logistics of when laboratory results were requested by providers and if the patients with diabetes filled the laboratory requests. These additional variables may have potentially been able to explain more of the variability in the results. Other variables like body mass index could have been included in this study, however, it was advised that the number of analysis to be limited and, therefore, a select number of variables were taken into consideration. Haemoglobin A1C, ACR, LDL, blood pressure and medication prescribed were

considered since they are important measures when managing diabetes, frequently recorded and easily collected from CPCSSN.

Another limitation in this study was distinguishing whether or not some quality of care indicators were *not recorded* or *missing*. It is possible to have outcome data that was measured and not recorded or measured and not recorded correctly; these are issues that accompany electronic medical records and other similar data systems[26]. Missing data can reduce the representativeness of the sample and potentially distorting inferences about the target population[26]. In this study, haemoglobin A1c for example was coded as *not recorded* if there was no entry in patient's electronic medical record for the past 12 months. There is a possibility that the haemoglobin A1c test was requested by the provider and the patient did complete the test, or the patient did complete the test but the results were not entered into the patient's electronic medical record. However, since the selected nine quality of care indicators in this study are considered to be standard procedure; providers are likely to enter the results into the patient's electronic medical records if measurements were taken. For example, unlike mental health issues, blood pressure is a standard measure for patients with diabetes during every visit to the clinic. It is likely that it will be take and recorded by the provider, so if blood pressure was coded as *not recorded*, it is likely that it was not measured by the provider as oppose to it was *missing* (measured but results were not recorded). Furthermore, data that is missing completely at random reduces the amount of information in the sample but does not usually bias the results. Systematically missing data, however, is far more likely to bias the results of the investigation[26]. Most of the *missing* data, or *not recorded* data in this study, was missing at

random because there were no notable differences between individuals with the missing data and individuals without the missing data.

Generalizability of results was another issue to be considered. Data was limited to one Kingston network (Center of Studies in Primary Care) and only included patients with diabetes that belonged to one practice. Patients with diabetes who were: attached to other practices; without a family physician; visiting walk-in clinics or hospitals were excluded. In addition, there was a difference in the nature of clinical practice from which the patients with diabetes were selected. The practice focused on training medical residents, which can be viewed as a different type of care from a regular practice; the quality of care may be different since more time may be spent with patients in a teaching clinic. Results of this study will be more relevant to teaching clinics than regular primary care clinics. On the other hand, the results of this study can be generalized because: a) the management of diabetes indicators are standardized and published in the Clinical Practice Guidelines for the Prevention and Management of Diabetes in Canada and all healthcare providers should be aware of these guidelines regardless of where they practice in Canada; and b) from a biological perspective, the progression of diabetes as a chronic disease is the same regardless of an individual's location of residence.

5.4 Implication for Research and Practice

5.4.1 Implication for Research

This study was unable to include a larger number of patients with diabetes. Also, a large number of the patients with diabetes were excluded from the population sample due to lack of

valid postal codes. To ensure that research will adequately detect the effects of deprivation on the quality of care, future studies require larger sample size with full valid postal codes. Also, deprivation scores based on the Pampalon deprivation index needs to be calculated using the more recent Canadian Census data to improve the validity of results.

The variation in patient management by healthcare provider was extremely small in this study. The study was focused on a teaching clinical practice that may not represent the many non-teaching clinical practices. Future studies need to include a variety of clinical practices to better assess the effects of the clinical practice on the quality of care for the patients with diabetes.

Important gender differences in the quality of care were identified in this study. For example, males with diabetes were prescribed ACE inhibitors and ARBs significantly more than females with diabetes. The reasons for these differences were not clear. Further studies are needed to explore these potential gender differences.

Finally, potentially important variables related to a patient's comorbidities and additional quality of care indicators, such as physical activity and smoking status, were not available for this study. These additional variables are suggested to have a strong influence on the health of individuals with diabetes by many including the Canadian Diabetes Association and, therefore, can be used as quality of care indicators. Future studies need to consider more quality of care indicators to further explore the quality of care received by patients with diabetes.

5.4.2 Implication for Practice

Gender difference in achieving suggested normal targets were evident in this study. Males with diabetes were much less likely than females to control their blood glucose and to have a normal ACR. These gender differences should be taken into consideration when planning treatment for patients with diabetes.

Earlier studies suggested that programs designed to meet the needs of patients with diabetes should take the level of an individual's deprivation into consideration to assure complete benefit from interventions[8,35,44]. Level of deprivation, however, was not observed to greatly influence the quality of care for patients with diabetes and this may be attributed to the limitations of this study. Nevertheless, as the prevalence of diabetes continues to increase, efforts are needed to gain greater understanding of how material and social deprivation may affect the health of individuals with diabetes.

Finally, it is important to make information about quality of care available to health care providers so that they improve their understanding of their patients and enable them to follow a more tailored care approach based on individual needs. When providers are competent in the many factors influencing a patient's state of diabetes, then quality of care can be improved as well as patient-provider trust and communication[49]. This will ultimately encourage patients to adhere to prevention and treatment methods[49].

5.5 Conclusion

Quality of care indicators can illustrate to what extent advances in health care are implemented in day-to-day practice[40]. These indicators can vary for a variety of reasons including patient gender and patient socioeconomic status. Patients with diabetes were selected as a model population to assess quality of care indicators in primary care practice.

This study found that the majority of the patients with diabetes resided in both the most deprived neighbourhoods and the least deprived neighbourhoods, and patients with diabetes who were from the most deprived neighbourhoods were less likely to have their low-density lipoproteins within the suggested target range. It is reassuring that no other important differences were identified in the quality of care by material and social deprivation. Nevertheless, substantial proportion of patients with diabetes was missing their suggested normal targets. There were also some gender differences in the extent that women with diabetes were less likely than men with diabetes to have their low-density lipoproteins under control and be prescribed ACE inhibitors or ARBs. However, women with diabetes were more likely than men with diabetes to have their most recent haemoglobin A1c within normal range and have their most recent albumin creatinine ratio within normal range. These results have shown that sentinel surveillance data in primary care has the capacity to identify directions for practice and research.

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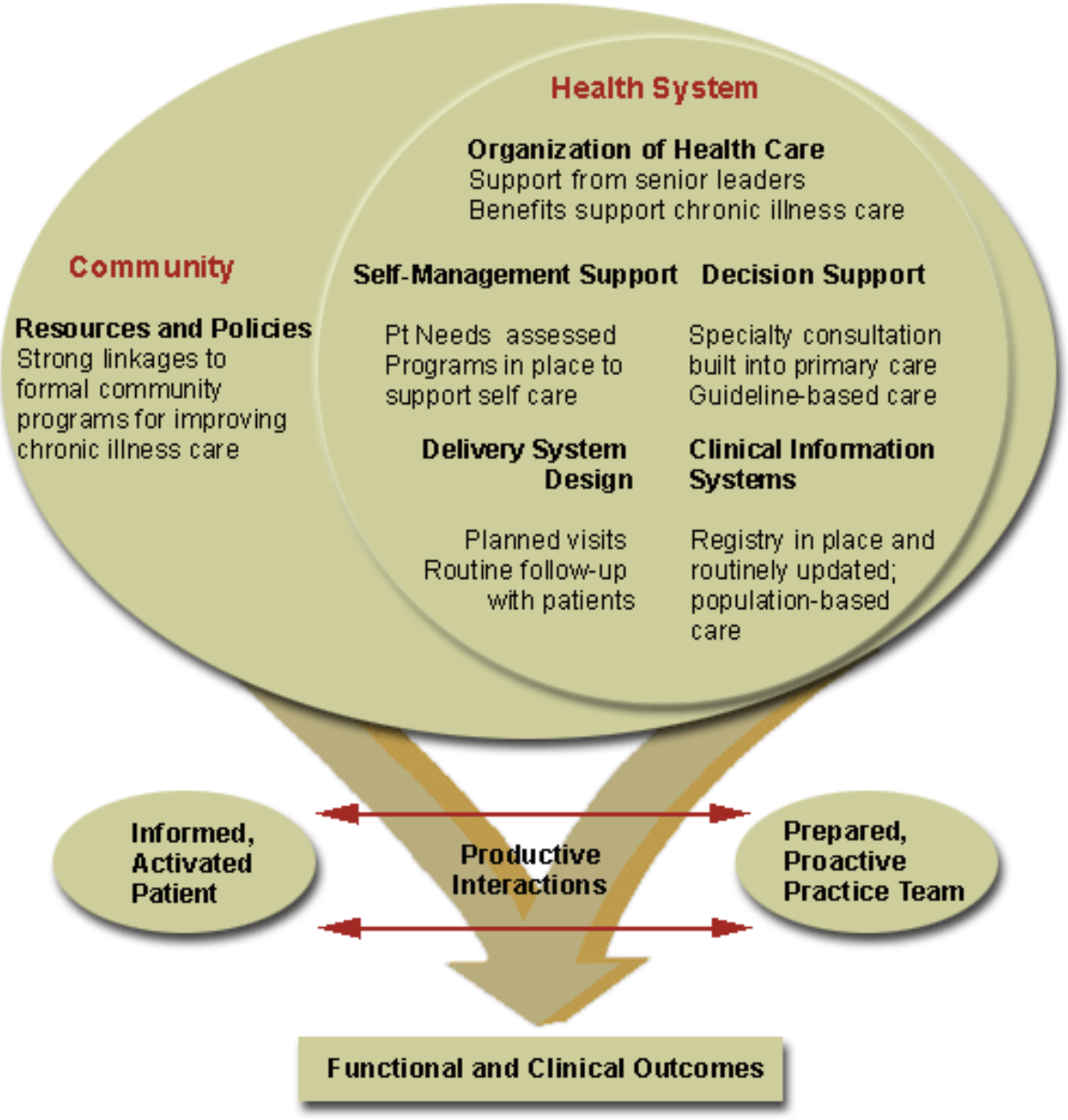
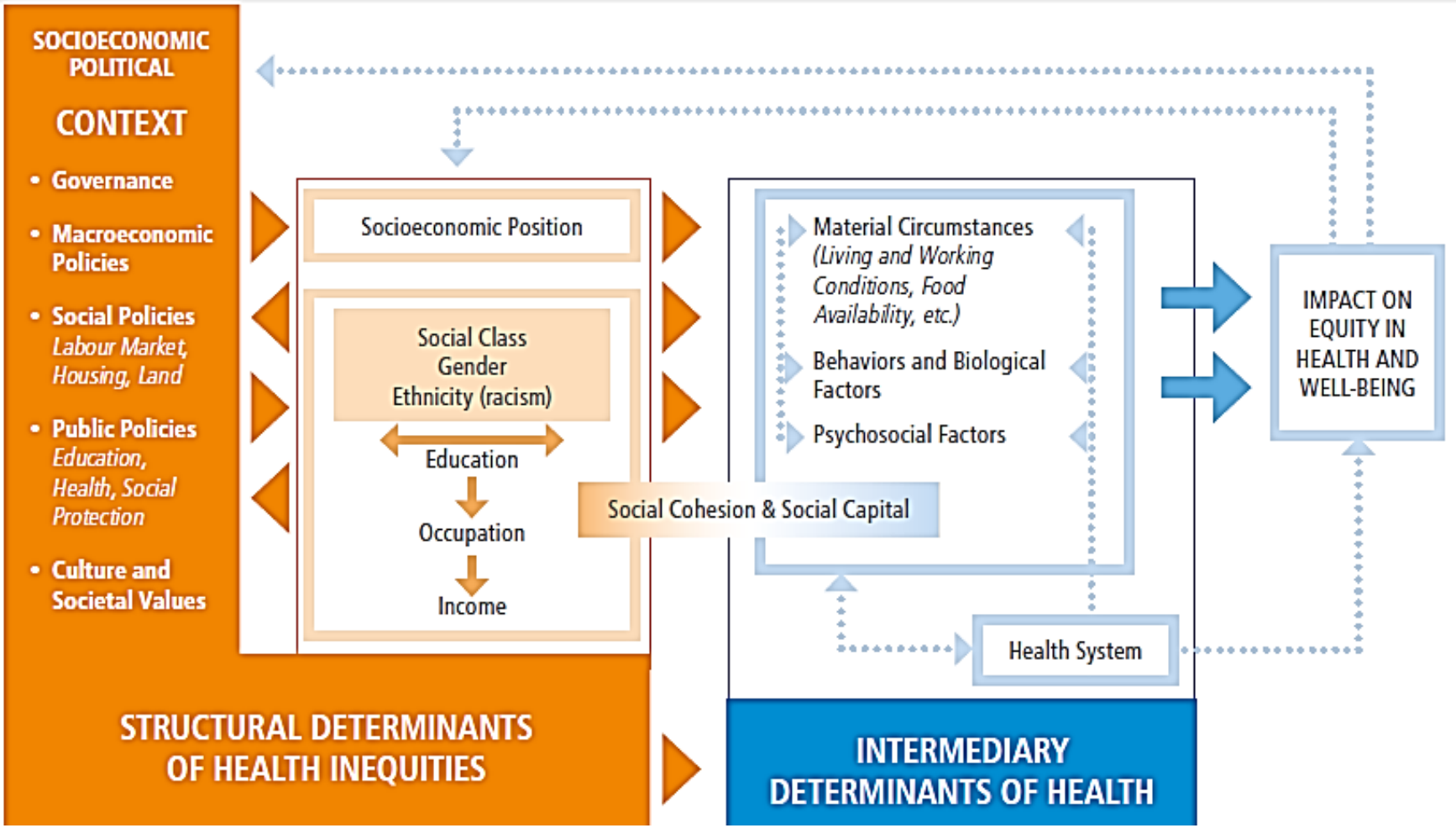
Appendices

Appendix 1: The Chronic Care Model



Appendix 2: Conceptual Framework of the Social Determinants of Health



Appendix 3: Sample Diabetes Patient Care Flow Sheet for Adults

Sample Diabetes Patient Care Flow Sheet For Adults

Name:	**Type of diabetes:** Type 1 ☐ Type 2 ☐ Other ☐	**Date of birth:**	**Date of diagnosis:**

Risk factors, co-morbidities

☐ Hypertension ☐ Dyslipidemia ☐ Coronary Artery Disease
☐ Peripheral Artery Disease ☐ Chronic Kidney Disease
☐ Mental health diagnosis ☐ Polycystic Ovary Syndrome
☐ Foot disease ☐ Erectile Dysfunction
☐ Smoking _____ (Date stopped)
☐ Alcohol: _____ (Assess/discussed)

Vaccinations

Flu (annual) Date: _____ Date: _____
Pneumoccocus Date: _____

Self-Management (discuss with patient; add date and location in chart)

Patient Goals: _____
Possible Barriers to Self-Management: _____
Diabetes Self-Management Education: _____
☐ Weight Management:
Ht: _____ Target Wt: _____ Target BMI: _____
☐ Physical Activity (aerobic 150 min/week; resistance 2-3 times/week)
_____
☐ Glucose Meter/lab comparison
☐ Patient Care Plan (Pregnancy Planning/Driving License):
_____ Date discussed

Visits (Every 3 to 6 months)

Date	**BP**	**Weight**	**A1C Target ≤7% or _____**	**Notes** (Goals, clinical status)	**Hypo-glycemia**	**Antihyperglycemic Agents / CV protection agents** (ACEi / ARB / Statin / ASA as indicated*)

Review SMBG records. Target: pre-prandial 4-7 mmol/L; 2-hour post-prandial 5-10 mmol/L (5-8 mmol/L if A1C not at target)

Screen for diabetes complications annually or as indicated

Nephropathy

Date	**ACR**	**eGFR**

Neuropathy

- Check feet for lesions and sensation (10-g monofilament or 128 Hz tuning fork)
- Check for pain, ED, GI symptoms

Date: _____ Findings: _____
Date: _____ Findings: _____
Date: _____ Findings: _____

Retinopathy

Annual eye exam:
Date: _____
Date: _____

Ophthalmologist/
Optometrist:
_____

***For vascular protection:**

☐ Statins if ≥40 yrs OR >30 yrs and >15 yrs duration OR end organ damage
☐ ACEi/ARB if ≥55 yrs OR end organ damage (even in the absence of hypertension)

Lipids Targets: If indicated to treat LDL-C ≤2 mmol/L

Date	Medication	LDL-C	HDL-C	TG	(Non-HDL-C)	(Apo B)

CAD Assessment

ECG: _____
Stress ECG: _____
Other: _____

See reverse side for care objectives and targets

Care	Objective	Target
Self-monitoring of Blood Glucose	Ensure patient can use glucose meter, interpret results and modify treatment as needed. Develop a blood glucose monitoring schedule with patient and review records.	Premeal (mmol/L) = **4.0-7.0 mmol/L for most patients** 2hr Postmeal (mmol/L) = **5.0-10.0 mmol/L for most patients** **5.0-8.0 mmol/L** if not achieving A1C target
Blood Glucose Control	Measure **A1C every three months** for most adults. Consider testing at least every 6 months in adults during periods of treatment and lifestyle stability when glycemic targets have been consistently achieved.	A1C **≤7.0% for most patients.** Individualized based on life expectancy, functional dependency, extensive coronary artery disease at high risk of ischemia, multiple comorbidities, recurrent severe hypoglycemia, hypoglycemia unawareness, longstanding diabetes unable to achieve A1C ≤7% despite best efforts (including intensified insulin).
Hypoglycemia	Enquire about hypoglycemia at each visit. Discuss recognition and treatment of hypoglycemia and risk/ benefit of hypoglycemia and pharmacologic management.	Avoidance of hypoglycemia especially in the elderly, those with hypoglycemia unawareness, and those with criteria for less stringent control.
Blood glucose meter accuracy	Meter results should be compared with laboratory measurements at least **annually**, and when indicators of glycemic control do not match meter.	Simultaneous fasting glucose/meter lab comparison within **20%.**
Hypertension	Measure BP at **diagnosis and at every diabetes clinic visit**	**<130/80**
Waist Circumference	Measure as an indicator of abdominal fat	Central obesity defined as: WC **M ≥102cm W ≥88cm** (North America) WC **M ≥94cm W ≥80cm** (Europids; Middle-Eastern; Sub-Saharan African; Mediterranean) WC **M ≥90cm W ≥80cm** (Asians; Japanese; South and Central Americans)
Body Mass Index	Calculate BMI (mass in kilograms/height in metres^2)	Healthy body weight target: **BMI: 18.5-24.9**
Nutrition	Encourage nutritional therapy (by a registered dietitian) as an integral part of treatment and self-management.	Meet nutritional needs by following **Eating Well with Canada's Food Guide**
Physical Activity	Discuss and encourage aerobic and resistance exercise. Evaluate those with possible CAD or microvascular complications undertaking exercise substantially more vigorous than brisk walking.	Aerobic: **≥150 minutes /week** Resistance: **3 sessions/week**
Smoking	Encourage patient to stop at each visit; provide support as needed.	**Smoking cessation**
Chronic Kidney Disease (CKD)	Identification of CKD requires screening for **proteinuria** using random urine **ACR** (2 out of 3 samples over 3 mths) and **assessment of renal function** using a serum creatinine converted to **eGFR**. **Type 1 diabetes**-Screen at 5 years duration and then annually if no CKD. **Type 2 diabetes**-Screen at diagnosis and then yearly if no CKD.	**Normal ACR <2.0 mg/mmol** **Normal eGFR >60 mL/min**
Retinopathy	**Type 1 diabetes**-Screen 5 years after diagnosis, then rescreen annually **Type 2 diabetes**-Screen at diagnosis and 1-2 years after initial screening if no retinopathy is present. The interval for follow-up assessment should be tailored to the severity of the retinopathy. Screening should be conducted by an experienced eye care professional.	Early detection and treatment
Neuropathy/Foot Examination	**Type 1 diabetes**-Screen 5 years duration and annually **Type 2 diabetes**-Screen at diagnosis, then annually Screen for neuropathy with 10-g monofilament or 128 Hz tuning fork at dorsum of great toe. In foot exam look for: structural abnormalities, neuropathy, vascular disease, ulceration, infection.	Early detection and treatment. If neuropathy present: require foot care education, specialized footwear, smoking cessation. If ulcer present: manage by multidisciplinary team with expertise
Coronary Artery Disease (CAD)	**Conduct CAD risk assessment periodically:** CV history, lifestyle, duration of DM, sexual function, abdominal obesity, lipid profile, BP, reduced pulses, bruits, glycemic control, retinopathy, eGFR, ACR. **Baseline ECG and every 2 years if** >40 years, >30 years and duration >15 years, end organ damage, cardiac risk factors.	**Vascular Protection:** First priority in prevention of diabetes complications is **reduction of cardiovascular risk by vascular protection** through a comprehensive multifaceted approach **All people with DM:** optimize: BP, glycemic control and lifestyle **Statin if:** age ≥40 years OR macrovascular disease OR microvascular disease OR long duration of DM (DM >15 years and age >30 years) **ACEi or ARB if:** age ≥55 years OR macrovascular disease OR microvascular disease
Dyslipidemia	**Fasting lipid levels (TC, HDL, TG and calculated LDL)** at diagnosis, then yearly if treatment not initiated. More frequent testing if treatment initiated.	Lipid targets for those who need therapy: **Primary target: LDL ≤2.0 mmol/L or ≥50% reduction** **Alternate Primary target: apo B ≤0.8 g/L or non-HDL-C ≤2.6 mmol/L**
Care Objectives: People with diabetes will have better outcomes if primary care providers 1) identify patients with diabetes in their practices 2) encourage self-management and use interdisciplinary team approach to attain care objectives 3) schedule diabetes-focused visits 4) use diabetes patient care flow sheets and systematic recall.		

Appendix 4: Final Dataset Including the Outcomes, Exposures and Covariate Variables

Data not available

_N_	Patient_ID	LDL	HBA1C	ACR	BP	LDL_Rec	HBA1C_Rec	QMAT	QSOC	CIHI5Cmb	pt_age	p_sex	Hypertension	……
1	12345678	.	.	.	.	0	0	2	5	4	89	0	1	
2	12263679	.	.	0	1	0	0	1	3	1	77	0	1	
3	12345563	0	1	1	0	1	1	1	4	2	75	0	1	
4	12309278	0	0	.	0	1	1	5	4	5	64	1	0	
5	12342854	1	0	.	0	1	1	5	4	5	81	0	1	
6	12354633	1	0	.	0	1	1	5	5	5	60	0	0	
7	12669978	1	1	1	0	1	1	3	1	1	74	0	1	
8	12345544	.	.	.	0	0	0	1	1	1	80	1	1	
…	….	….	….	….	…	….	….	….	….	….	….	….	….	
975	12359457	0	1	1	0	0	1	5	3	4	50	0	1	

Variables included in the final dataset:

- **_N_** (count of patients with diabetes=975. One line of observations per patient)
-Patient ID (patients diagnosed with diabetes for at least one year)
-LDL (Most recent laboratory results of *Low Density Lipoproteins*: At Target=1 /Above Target=0)
-HBA1C (Most recent laboratory results of *Haemoglobin A1c*: At Target=1 /Above Target=0)
-ACR (Most recent laboratory results of *Albumin Creatinine Ratio*: At Target=1 /Below Target=0)
-BP (Most recent measure of *Blood Pressure*: At Target=1 /Above Target=0)
-LDL_Rec (Low Density Lipoproteins: Recorded=1/Not Recorded=0 within last 12 months)
-HBA1C_Rec (Haemoglobin A1c: Recorded=1/Not Recorded=0 within last 12 months)
-ACR_Rec (Albumin Creatinine Ratio: Recorded=1/Not Recorded=0 within last 12 months)
-BP_Rec (Blood Pressure: Recorded=1/Not Recorded=0 within last 12 months)
-ACE_ARB (ACE inhibitors/angiotensin receptor blockers: prescribed=1/not prescribed=0)
-QSOC (calculated quintile for social deprivation)
-QMAT (calculated quintile for material deprivation)
-CIHI5CMB (calculated quintile for combined social and material deprivation)
-Pt_sex (patient sex: 0=male, 1=Female)
-P_sex (Provider sex: : 0=male, 1=Female)
-**Pt_age** (Patient age in years)
-P_age (provider age in years)
-Hypertension (patients with diabetes and Hypertension=1/ without Hypertension=0

Appendix 5: Sample Size Calculation

Sample sizing exercise was conducted to ensure that the available sample size was sufficient for this investigation. As the data are inherently clustered, the following sample size formula was used:

SAMPLE SIZE FORMULA

$$n = (1 + (m-1)\rho)\left[\frac{\left(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta}\right)^2 \, 2(\bar{P})(1-\bar{P})}{(P_1 - P_2)^2}\right]$$

Where m is the cluster size, ρ is the intercluster correlation (ICC), $\bar{P}$ is the average proportion, P_1 and P_2 are the outcome proportions, $Z_{1-\frac{\alpha}{2}}$ is 1.96, and $Z_{1-\beta}$ is 0.84

Assuming the following:

- an ICC of 0.05, which is a conservative estimate for primary care practices[30]
- a minimum clinically meaningful difference of 0.10
- an average cluster size of about 100 patients per physician (22 physicians with 100 patients each on average)
- an average outcome of 0.5. If we consider that all outcomes are binary and equally important; then we assume baseline proportion of the outcomes - which is the most conservative approximation

Then the required sample size is 2325 – well below the 2471.

If we assume that the ICC is actually much higher at 0.10, this would require sacrificing the detectable difference to be 0.15, but then the required sample size is 1893 – also below 2471.

Therefore, it is reasonable to assume that the sample of 2471 individuals will provide sufficient power to detect a difference of greater than 0.10.

Appendix 6: Exposures, Outcomes, Effect Modifiers and Confounders

Exposure	Outcomes	Effect Modifiers & Confounders
Objective 1: Combined Material and Social Deprivation	*Recorded (or not)* -Haemoglobin A1c -LDL -BP -ACR -ACE-1/ARB treatment *On Target (or not):* -Haemoglobin A1c ≤7.0% -LDL ≤2.0mmol/L -BP <130/80 mmHg -ACR[1]	-Sex -Age -Hypertension
Objective 2: Patient Sex	*Same as Objective 1*	-Age -Hypertension -Deprivation quintiles

[1] ACR At Target: Female <2.8 mg/mmol, Male <2.0 mg/mmol)

Appendix 7: Research Ethical Board Approval Letter

QUEEN'S UNIVERSITY HEALTH SCIENCES & AFFILIATED TEACHING HOSPITALS RESEARCH ETHICS BOARD-DELEGATED REVIEW

January 23, 2013

Ms. Amal Al Zayadi
Department of Community Health and Epidemiology
Carruthers Hall,
Queen's University

Dear Ms. Al Zayadi

Study Title: EPID-412-13 Impact of Deprivation on the Management of Diabetes in Primary Health Care File # 6007673
Co-Investigators: Dr. D. Hunter, Dr. T. Williamson, Dr. R. Birtwhistle

I am writing to acknowledge receipt of your recent ethics submission. We have examined the protocol and consent form for your project (as stated above) and consider it to be ethically acceptable. This approval is valid for one year from the date of the Chair's signature below. This approval will be reported to the Research Ethics Board. Please attend carefully to the following listing of ethics requirements you must fulfill over the course of your study:

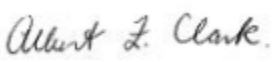
Reporting of Amendments: If there are any changes to your study (e.g. consent, protocol, study procedures, etc.), you must submit an amendment to the Research Ethics Board for approval. Please use event form: HSREB Multi- Use Amendment/Full Board Renewal Form associated with your post review file # **6007673** in your Researcher Portal (https://eservices.queensu.ca/romeo_researcher/)

Reporting of Serious Adverse Events: Any unexpected serious adverse event occurring locally must be reported within 2 working days or earlier if required by the study sponsor. All other serious adverse events must be reported within 15 days after becoming aware of the information. Serious Adverse Event forms are located with your post- review file **6007673** in your Researcher Portal (https://eservices.queensu.ca/romeo_researcher/)

Reporting of Complaints: Any complaints made by participants or persons acting on behalf of participants must be reported to the Research Ethics Board within 7 days of becoming aware of the complaint. Note: All documents supplied to participants must have the contact information for the Research Ethics Board.

Annual Renewal: Prior to the expiration of your approval (which is one year from the date of the Chair's signature below), you will be reminded to submit your renewal form along with any new changes or amendments you wish to make to your study. If there have been no major changes to your protocol, your approval may be renewed for another year.

Yours sincerely,



Chair, Research Ethics Board
January 23, 2013

Investigators please note that if your trial is registered by the sponsor, you must take responsibility to ensure that the registration information is accurate and complete

QUEEN'S UNIVERSITY HEALTH SCIENCES & AFFILIATED TEACHING HOSPITALS RESEARCH ETHICS BOARD

The membership of this Research Ethics Board complies with the membership requirements for Research Ethics Boards and operates in compliance with the Tri-Council Policy Statement; Part C Division 5 of the Food and Drug Regulations, OHRP, and U.S DHHS Code of Federal Regulations Title 45, Part 46 and carries out its functions in a manner consistent with Good Clinical Practices.

Federalwide Assurance Number: #FWA00004184, #IRB00001173

Current 2012 membership of the Queen's University Health Sciences & Affiliated Teaching Hospitals Research Ethics Board:

Dr. A.F. Clark, Emeritus Professor, Department of Biochemistry, Faculty of Health Sciences, Queen's University (Chair)

Dr. H. Abdollah, Professor, Department of Medicine, Queen's University

Dr. R. Brison, Professor, Department of Emergency Medicine, Queen's University

Dr. C. Cline, Assistant Professor, Department of Medicine, Director, Office of Bioethics, Queen's University, Clinical Ethicist, Kingston General Hospital

Dr. M. Evans, Community Member

Dr. S. Horgan, Manager, Program Evaluation & Health Services Development, Geriatric Psychiatry Service, Providence Care, Mental Health Services, Assistant Professor, Department of Psychiatry

Ms. J. Hudacin, Community Member

Dr. J. MacKenzie, Pediatric Geneticist, Department of Paediatrics, Queen's University

Mr. D. McNaughton, Community Member

Ms. P. Newman, Pharmacist, Clinical Care Specialist and Clinical Lead, Quality and Safety, Pharmacy Services, Kingston General Hospital

Ms. S. Rohland, Privacy Officer, ICES-Queen's Health Services Research Facility, Research Associate, Division of Cancer Care and Epidemiology, Queen's Cancer Research Institute

Dr. B. Simchison, Assistant Professor, Department of Anesthesiology and Perioperative Medicine, Queen's University

Dr. A. Singh, Professor, Department of Psychiatry, Queen's University

Dr. J. Tang, Medical Resident, Department of Emergency Medicine, Queen's University

Ms. K. Weisbaum, LL.B. and Adjunct Instructor, Department of Family Medicine (Bioethics)