University of Alberta

Socioeconomic Disparities in Eye Care Services and Eye Complications Among Diabetic Patients in Canada

by

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Dedication

This thesis is dedicated to my lovely parents, for their love and support throughout my life, and for raising me to be the person I am today.

Abstract

Diabetic retinopathy (DR) is a major cause of visual impairment that ultimately impedes daily activities. Visual impairment caused by DR is manageable if diagnosed early. Despite comprehensive clinical guidelines, there is underuse of the recommended eye examinations among patients with diabetes in Canada. This dissertation comprises of four studies identifying 1) the existence of disparities in eye care services and visual impairment, 2) the socio-demographic determinants of socioeconomic disparities in eye care services and visual impairment, and 3) the socioeconomic factors associated with visual impairment and eye screening services among patients with diabetes.

The results of three separate analyses indicate the presence of 1) socioeconomic disparities in eye care services at the provincial level and 2) income-related disparities in visual impairment and eye screening services at the national level. At the provincial level, income- and material deprivation-related disparities consistently showed a "pro-rich" pattern, while the social deprivation index indicated a "pro-poor" pattern. In addition, material deprivation index and place of residence (urban/rural) were important contributors to the observed income- and material deprivation-related disparities. The social deprivation-related disparity was explained mainly by social deprivation itself.

At the national level, income-related disparities in eye screening services and preventive eye screening services revealed a "pro-rich" pattern while the disparity in visual impairment indicated a "pro-poor" pattern. The main contributor to the observed disparities in eye screening services was income while the disparity in visual impairment was predominantly related to age.

In addition, an examination of socioeconomic factors associated with visual impairment and eye screening services among Canadians living with diabetes provided further evidence that demographic factors and duration of diabetes were associated with visual impairment. Regarding eye screening services and preventive eye screening services, income, patient's experience in discussing diabetic eye complications with health professionals and having private insurance covering eye care appointment were associated with regular eye screening services.

We have contributed new evidence on previously unexplored issues and our work highlights a need for developing health policy to alleviate the gap in the use of eye examination across different socioeconomic groups, and for studies providing a better understanding of the observed disparities.

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List of Abbreviations

AAO	American Association of Ophthalmology
ADA	American Diabetes Association
ADSS	Alberta Diabetes Surveillance System
AHS	Alberta Health Services
AHW	Alberta Health Wellness
CC	Concentration curve
CDA	Canadian Diabetes Association
CHA	Canadian Health Act
CNIB	Canadian National Institute for the Blind
DM	Diabetic mellitus
DR	Diabetes retinopathy
ETDRS	Early Treatment of Diabetic Retinopathy Study
FSA	Forward Sortation Area
HBM	Health Behaviour Model
HI	Horizontal inequity index
ICD	International Classification of Disease
MDI	Material deprivation index
NSPB	National Society to Prevent Blindness
NPDR	Non-proliferative diabetic retinopathy
OR	Odds ratio
PCA	Principal component analysis
PDR	Proliferative diabetic retinopathy
RCI	Relative Concentration Index

SDI Social deprivation index

SES Socioeconomic status

SLCDC Survey on Living with Chronic Disease in Canada

Chapter 1. Introduction

1.1 Diabetes and Diabetic Complications

Diabetes is a common chronic disease responsible for significant morbidity and mortality in Canada. Approximately 6.2% of Canadians live with diabetes; Alberta's prevalence is somewhat lower at 5.7% in 2009 (1-3). The prevalence of diabetes is expected to continuously increase (4). Several risk factors have been identified as contributing to the increasing prevalence of diabetes and its complications: the general aging of the population, and increasing rates of obesity, physical inactivity, and hypertension (4).

The increasing prevalence of diabetes is a substantial concern due to its related long-term complications such as ischemic heart disease, stroke, renal failure, neuropathy and retinopathy that directly affect individuals' daily lives (5-8). These long-term complications of diabetes are generally grouped into macro- and microvascular complications. Macrovascular refers to the cardiovascular system, including heart disease, hypertension and cerebrovascular disease. Macrovascular complications are the leading cause of morbidity and mortality in people with diabetes. Indeed, patients with diabetes are two to three times more likely to suffer cardiovascular disease (8-10) and three times more likely to die of ischemic heart disease than are non-diabetic patients of similar age and sex (11). Also, people with diabetes have about twice the prevalence of hypertension and twice the incidence of stroke compared to people without diabetes (3, 6).

Diabetic retinopathy (DR) is a common and specific microvascular complication of diabetes (12-15). At 20 years after the initial diagnosis, almost every patient with type 1 diabetes, and 60% of people with type 2 diabetes will have some degree of diabetic retinopathy and, after 30 years, almost all are affected (16). DR is classified into two main groups: an early stage, non-proliferative diabetic retinopathy (NPDR) and a more severe stage, proliferative diabetic retinopathy (PDR) (17). Both NPDR and PDR are associated with worse health outcomes for people with diabetes. NPDR causes vision impairment through increased intra-retina vascular permeability that ultimately induces macular edema and variable degrees of intra-retinal capillary closure, causing macular ischemia. The development of PDR is associated with an increased risk of myocardial infarction, stroke, diabetic nephropathy, and amputation (17, 18).

DR is the leading cause of blindness in North America (19). It is responsible for about 12% of all new cases of blindness, affecting more than 8,000 individuals each year in the United States (13). In Canada, DR causes an estimated 600 new cases of blindness each year (20). Considering the increasing number of diabetic patients in the Canadian population, it is anticipated that the prevalence of DR and blindness will continuously increase (21). It has also been estimated that nearly half a million Canadians currently have some form of DR and approximately 100,000 Canadians have PDR, diabetic macular edema or both (19). Visual impairment and blindness caused by DR are important causes of decreased quality of life (22) and low involvement in the labour force (16). Vision impairment caused by DR is preventable and made more manageable when the disease is detected and treated early in its course; however, once vision loss develops, it is less likely to be recovered (18, 23, 24).

1.2. Screening for Diabetes Retinopathy

Routine screening for DR is recommended in many countries based on intervention and economic studies. The Canadian Diabetes Association (CDA) recommends an annual dilated eye examination to prevent potential vision loss (14). Screening for DR is highly effective, economical, and available under the universal health care system in Canada (12). Screening guidelines for DR have been also supported by professional organizations in the United States such as the American Diabetes Association (ADA), and the American Association of Ophthalmology (AAO) (25). In the U.K., screening for DR is offered as a national program to reduce the risk of vision loss in people with diabetes (16). Despite established comprehensive guidelines for routine screening for DR, underuse of recommended eye screening services is commonly reported among diabetic patients from different countries, regardless of the type of health care system (24, 26-28).

The gold standard for the detection of DR consists of 30-degree, seven-field, stereoscopic photography, as developed for the Early Treatment of Diabetic Retinopathy Study (ETDRS) (25). This has a sensitivity and specificity for the detection of DR that is superior to direct and indirect ophthalmoscopy by ophthalmologists. Examinations can also be done using retinal photographs (with or without dilation of the pupil) that are read by experienced experts in this field (25). In Canada, the current standard of care for identification of DR is a stereoscopic assessment of the retina through a dilated pupil by an experienced eye care professional (12, 14). In addition, teleophthalmology programs have been developed to provide as a modified ETDRS protocol for screening patients living in remote areas (29-31).

1.3. Definitions of Inequality and Inequity in Health and Health Care

While the terms disparity, inequality and inequity are often used interchangeably in literature, it is critical to distinguish the concepts and definitions of these three terms. Disparity is a neutral term used to designate any difference between group and it implies little implication of social value or justice (32). Either inequality or inequity can be described as disparity. Inequality is used to explain a difference or variation in health status or in the distribution of determinants associated with health and health care between individuals or groups (33). The concept of inequality is not necessarily value based, so it is more likely a descriptive term without moral judgement (34). An example of inequality is differences in health outcomes that result from biological endowment, such as sex. In contrast, health inequity is a difference in health or health care, which is not justified on the basis of need, as a result of unfairness or injustice in a society (33-35). Inequity is considered an avoidable and unnecessary difference between different groups (33, 36). It was suggested that inequality and inequity are not synonymous (34), and these terms are required to be distinguished in health and health care research (33).

1.4. Inequities in Health and Access to Health Care Services

Accumulating evidence indicates that poor SES is associated with worse health outcomes and underuse of preventive health care services in the general population (37-42). Lower income, lower educational attainment, lower wealth, and less privileged occupation at the individual level have been identified as predictors of inequities (38, 43). In addition, SES factors contributing to inequities in health and health care encompass not only individual characteristics, but also community-level characteristics and gradients of socioeconomic status between individuals and communities (44). These factors can be conceptualized and measured over an individual's lifetime (44).

Rigorous research has provided evidence on the relationship between SES and the prevalence of diabetes and diabetic complications. Dinca-Panaitescu et al. observed a graded association between SES (based on income and educational level) and prevalence of diabetes, confirming that social and economic status are important factors influencing the prevalence of diabetes in Canada (45). Rabi et al. also reported a significant gradient in prevalence of diabetes across income groups (46). In addition, evidence from rural Manitoba suggests that this SES-related gradient in prevalence of diabetes has widened over the last 20 years (47). There is also evidence of higher rates of diabetes-related amputations in lower income neighbourhoods (47).

1.5. Inequities in Diabetic Eye Complications and Eye Screening Services

Internationally, SES is a key predictor of increased rates of diabetic eye complications (46, 48-54). In their summary of the literature, Brown et al. found that lower SES, as measured by individual or household income, education, employment, occupation, or living in an underprivileged area, is associated with increased risk of microvascular disease, including ocular complications (44). Rates of ocular complications are also higher among minority groups, which tend to be of lower SES. A systematic review conducted in the United States reported that African Americans and Latinos have higher rates of blindness compared to the general population (52). Within the U.S. population of visible minority groups, an SES-related gradient has also been found: higher SES groups have better ocular health outcomes compared to those with lower SES (52). These findings are a result of multifaceted SES interaction, indicating that race/ethnicity, while related to ocular complications, is likely attributable in large part to SES (23, 53, 55-57).

Given this evidence, SES appears to be an important determinant of ocular complications in diabetic populations.

With respect to eye examination services, inequities in the use of eye screening services are observed among lower SES groups, regardless of the type of health care system (48, 51, 53). Moss et.al found that more education or higher income and having health insurance that covered eye examinations were predictors of receiving an eye examination in individuals with younger-onset diabetes (29). Another study found that a patient's educational level, health literacy, and language fluency were also identified as barriers to eye screening services by an ophthalmologist (53). Differences in utilization of recommended screening services by ethnic/racial groups also suggest a relationship with SES. For example, the underuse of recommended screening for DR observed in the Hispanic population could be explained by a phenomenon known as the "accumulative effect" (52). The accumulative effect refers to fact that systematic societal factors result in the greater likelihood that racial/language minorities will have lower income and live in poorer neighbourhoods or remote residential areas (40, 55).

Similar findings have been found in the U.K., a country with a publicly funded health care system, and in which there are important socioeconomic differentials in the utilization of preventive medical care, including DR screening, indicating that the rate of DR screening was significantly lower in patients residing deprived areas (23, 53, 54, 57) (54, 58, 59). Studies in Australia, Spain, and Hong Kong have also found that the groups at high risk of underutilization are those who are in poverty or have lower income (60). Overall, the accumulated evidence indicates a strong association between SES and utilization of eye screening services: lower SES, including lower income and education, poverty, and living in a poorer neighbourhood could be considered as predictors of use of recommended eye examination services in diabetic patients (25).

1.6. Diabetic Eye Complications and Eye Screening Services in Canada

Despite the growing body of literature on inequities in both health outcomes and health care services in Canada, there is little research focusing specifically on diabetic ocular complications and eye screening services. Several studies of the general population have documented that the proportion of people with uncorrected vision problems or blindness was highest for individuals in the lowest income and educational levels (22). In a recent Canadian pilot study, Gold et al. reported that the rising cost of visual aids present a significant barrier to vision rehabilitation service benefits for individuals on low or fixed incomes, particularly seniors (61). Sit et al., using Canadian National Institute for the Blind (CNIB) blindness registration data, suggested that, besides age, median household income is the most common predictors of blindness and poor ocular health outcomes (62). In another Canadian population-based study, along with age, being female and having a low income and lower educational attainment were associated with vision problems (22).

In the 2006 study of five provinces and one territory, Sanmartin et al. reported that only 68% of diabetic patients had self-reported receiving the recommended level of eye screening service (63). This study found that patients aged 18 to 44 were less likely to have had an eye examination compared with older patients (63). However, due to limited data collection and lack of information at the individual level, the study was unable to fully explain the possible causes of the underuse of eye examinations in younger patients. Another Canadian study that used population-based provincial data on ophthalmic services for persons with diabetes focused on determining both the direct and indirect costs of providing ophthalmic, social, and rehabilitative services for persons with diabetic ocular diseases; however, the study did not measure the association between SES and diabetic ocular diseases/ophthalmic services including recommended eye screening services in patients with diabetes (64).

The literature from several countries with different health care systems indicates that diabetic eye complications and use of eye screening services are consistently worse in diabetes patients with lower SES. It is unknown whether this same pattern exists among diabetic patients living in Alberta and Canada. Further research is required to establish the magnitude of health disparities between those of low, average, and high SES in order to identify and quantify the level of any inequities.

1.7. Objectives and Program of Research

The objective of this program of research was to measure socioeconomic-related disparities in visual impairment and eye screening services among patients with diabetes both provincially (in Alberta) and nationally. We sought to examine whether there are disparities in visual impairment and eye screening services across different socioeconomic indicators and to quantify each contribution of socio-demographic factors to the observed disparities at both levels. We were also interested in assessing whether any apparent disparities could be defined as either inequities or inequalities. A further objective was to identify factors associated with visual impairment and eye screening services among diabetic patients living in Canada.

The first two studies (Chapter 2 and 3) focus on eye care services by ophthalmologists in Alberta, using three different socioeconomic indicators - household income, material, and social deprivation indices. These studies utilized data from the Alberta Diabetes Surveillance System 1995-2009, which is based on Alberta Health administrative databases. Chapters 4 and 5 focus on visual impairment and eye screening services among patients with type 2 diabetes using the Survey on Living with Chronic Disease in Canada – Diabetes Component 2011 (SLCDC –DM 2011), which is a nationally representative survey dataset.

As a common approach to both data sources (i.e., provincial health care administrative data and national survey data), the relative concentration index (RCI) and decomposition analysis were used to address the objectives of our research to better understand disparities and inequities in visual impairment and eye care services. Using the SLCDC-DM data to better understand factors associated with visual impairment and eye screening services, multivariate logistic regression was also used to measure and quantify income-related disparities among patients with type 2 diabetes.

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Chapter 2. Socioeconomic Disparities in Eye Care Services among Diabetic Patients in Alberta, 1995-2009

Abstract

Diabetic retinopathy (DR) is a leading cause of blindness in Canada. Despite established comprehensive guidelines for routine DR screening, the rate of provision eye care services in diabetic patients in Alberta has decreased over the past years. Lower socioeconomic status (SES) has been identified as a factor associated with disproportionate use of health care services. While there is increasing evidence for unequal use of health care services by individuals with lower SES over the past decade, there is limited evidence regarding the relationship between lower SES and the use of eye care services by diabetic patients in Canada. The aim of this study was to examine socioeconomic status (SES)-related disparities in the use of ophthalmologists' services for diabetic patients in Alberta. We used data from the Alberta Diabetes Surveillance System (ADSS), including visits to ophthalmologists over a 15-year period (1995-2009). Socioeconomic disparities in the use of eye care services were assessed using the Relative Concentration Index (RCI), which ranges from -1 to +1. We used three different SES indicators: median household income and the Canadian material and social deprivation indices (MDI and SDI). We found that socioeconomic disparities in use of eye care services exist in diabetic patients, although the magnitudes of the disparities were small and have steadily decreased over time. Income- and MDI-related RCI indicated a "pro-rich" direction, suggesting that individuals with more income or less material deprivation were more likely to use eye care services. For SDI-related RCI, socially deprived individuals were more likely to use eye care services compared to less socially deprived groups (RCI: 1995:- 0.066; 2002:-0.036; 2009:-0.028). Socioeconomic disparities varied by Alberta Health Services (AHS) zones, and it was noteworthy that the pattern of change

in the different RCI varied also by sub-population, particularly in the non-Aboriginal population in the North zone. Our findings suggest policy development at the provincial level may be considered to alleviate the observed disparities in the use of eye care services among diabetic, particularly as it relates to geographical differences across AHS zones.

2.1. Introduction

Diabetic retinopathy (DR) is a common and serious life-threatening complication of diabetes (1-3). Nearly 60~80% of people with type 2 diabetes will have some degree of diabetic retinopathy 15 to 20 years after their initial diagnosis, and almost all are affected after 30 years (4, 5). DR is classified into two stages: an early stage, termed non-proliferative diabetic retinopathy (NPDR), and a more severe stage, termed proliferative diabetic retinopathy (PDR) (6). Both NPDR and PDR are associated with worse health outcomes. NPDR and PDR cause vision impairment through increased intra-retinal vascular permeability that ultimately results in macular edema and varying degrees of intra-retinal capillary closure, which causes retinal ischemia and neovascularization (6).

In addition to a higher risk of various complications (6), DR is the primary cause of blindness in North America (2). It is responsible for about 12% of all new cases of blindness, affecting more than 8,000 individuals each year in the U.S (7). In Canada, DR causes an estimated 600 new cases of blindness each year (8). One Canadian study has estimated that DR prevalence could be as high as 40% among patients with diabetes (7). Given the increasing number of patients with diabetes in Canada, the prevalence of DR is also expected to continuously increase (9). The visual impairment and blindness caused by DR are important causes of decreased quality of life (10) and a major impediment to labour force participation (4). Vision impairment caused by DR can be preventable and more manageable when the disease is detected and treated early in its course; however, once vision loss develops, it is less likely to be recovered (11-13).

Despite established comprehensive guidelines for routine screening, underuse of recommended eye care services has been observed in patients with diabetes (12, 14-16). Provincial diabetes surveillance data on eye examinations during the period of 2001-2006 indicates that only 48% of diabetic patients in Alberta received an eye examination by an ophthalmologist within 3 years of their diagnosis of diabetes (13). These lower rates are also observed in other parts of Canada. In Ontario, only 19% of patients with diabetes have undergone a follow-up eye examination after their initial eye exam (17).

Lower socioeconomic status (SES) has been associated with disproportionate use of eye care services. Moss et. al found that more education, higher income, and having health insurance that covers eye examination were predictors of receiving an eye examination in younger diabetic patients (16). In the U.K, which has a publicly funded healthcare system, the rate of DR screening was significantly lower in patients residing in deprived areas (18-20). The evidence for SES-related barriers to access to health care services (21-24) and a growing number of lower SES individuals during the past decade (25) directs our attention to the potential effects of lower SES on the use of eye care services among those living with diabetes. It has also been suggested that micro-level investigations focusing on specific service categories are needed to provide information that cannot be achieved by a macro-level study of health care equity (26).

Therefore, our study was designed to look for SES-related disparities in the use of eye care services in patients with diabetes living in Alberta over a 15-year period (1995-2009). In addition, we examined the geographic decomposition of socioeconomic disparities in eye care services among diabetic patients across different Alberta Health Services (AHS) zones.

2.2. Methods

Our study used data from the Alberta Diabetes Surveillance System (ADSS). The ADSS was created to disseminate information on the incidence, prevalence, and mortality, and complications of diabetes in Alberta, Canada (27, 28). The ADSS datasets are created by linking and de-identifying data from several Alberta Health (AH) databases including discharge abstract databases, the physician claims database, the ambulatory care classification system, and the population registry. All diabetic patients, diagnosed by physicians and covered by the provincial health care plan from 1995-2009 were included in the ADSS datasets. The case definition to identify diabetic patients requires that an individual must have one hospitalization with an International Classification of Disease, 9th revision (ICD-9) code of 250, selected from all available diagnostic codes from the hospital discharge abstract for the years 1995-2001, or equivalent ICD-10 codes (E10-E14) for the years after 2001-2002, or two physician claims with an ICD-9 code of 250 within 2 years, selected from any of the three available diagnostic codes from the physician claims database (27). Women with gestational diabetes were excluded (27). We included only diabetic patients over age 20 years who were classified as adult diabetic patients by the ADSS case definition, and individuals whose postal code were linkable to a specific neighbourhood.

We used three different SES indicators: median household income and the Canadian material and social deprivation indices (MDI and SDI) (28), linked to the ADSS datasets at Alberta's 70 sub-region levels. Median household income was obtained from 2006 Canadian census data. The Canadian MDI and SDI, also created based on 2006 Canadian census data, were developed to measure multiple dimensions of SES and are widely used as a measurement of SES (29). MDI is a composition of educational attainment, employment status and income level. SDI includes the prevalence of single-parent families as well as the proportion of people living alone, and those who are separated, divorced or widowed.

The use of eye care services provided by an ophthalmologist after the initial diagnosis of diabetes was measured by all contacts with ophthalmologists in each year from 1995-2009 (13). This includes any service or procedure performed by an ophthalmologist and claimed for reimbursement by Alberta Health [Table S2.1]. Until April 2007, optometrist services were not fully covered as an insured benefit and therefore not included in the physician claims database.

To examine SES-related disparities in eye care services by ophthalmologists, we used the Concentration Curve (CC), and the Relative Concentration Index (RCI). The CC and RCI were proposed by Kakwani and Wagstaff (30, 31) and are commonly used as standard measurement tools for socioeconomic-related inequality in the field of health economics and policy (32, 33). To present the CC, we plotted the cumulative percentage of the outcome variable (i.e., eye care services by ophthalmologists) on the y-axis, against the cumulative distribution of individuals by quintiles of SES indicator (i.e., each of household income, MDI and SDI) plotted on the x-axis. This curve allowed us to measure the distribution of eye care services by aggregating across individuals for SES-related quintiles. The line of equity (i.e., a 45-degree line) would represent an equal distribution of eye care services (i.e., 20%) across each of the five SES-related quintiles.

To quantify the magnitude of disparities in eye care services by ophthalmologists, we used the RCI, which is directly related to the CC (29,30). The RCI is defined as twice the area between the CC and the line of equity. The RCI is typically bounded between -1 and 1. When the outcome variable is dichotomous, the RCI bounds μ -1 and 1- μ, respectively, where μ is mean of the health care variable (34). The RCIs in the use of eye screening services among diabetic patients over the 15-year period were calculated based on the following equation (33, 35) :

$$C = \frac{2}{N\mu} \sum_{t=1}^{n} h_i r_i - 1 - \frac{1}{N}$$

Where h_I is the outcome, eye care services by ophthalmologists, μ is the mean of the outcome, and r_i=*i*/N is the fractional rank of individuals *I* in the median SES (i.e., household income, and MDI or SDI) distribution, with *i*=1 for the lowest and *i*=N for the highest. In the case in which there is no SES-related disparity (i.e., the CC equals the line of equity), the RCI is calculated as zero. By convention, the RCI takes a negative value when the curve lies above the line of equity, indicating disproportionate concentration of eye care services among the lowest quintiles (i.e., “pro-poor”), and a positive value when it lies below the line of equality (i.e., “pro-rich”). The greater value of the RCI means a greater degree of concentration in a negative or positive direction.

In addition, we examined geographic decomposition of socioeconomic disparities in eye care services across five different AHS zones (i.e., South, Calgary, Central, Edmonton, and North) in order to understand "between zone" and "within zone" contributions to income-and deprivation-related disparities. We compared the between and within zone variations in RCI using a method of decomposition of the RCI, based on the following equation (37, 38).

$$\mathrm{C} = C_B + \sum_i \alpha_i C_i + R$$

Where C is the calculated RCI, C_B is the between-zone RCI, α_i is the product of the each area's population share and its share of eye care services and C_i is the RCI of each AHS zone, and R is a re-ranking term. C_B is computed by assigning all individuals in a given zone with mean of value of the use of eye care services in that zone, rank ordering AHS zones by their mean per capita income, MDI or SDI, and computing the corresponding RCI for the use of eye care services. C_i indicates the extent of socioeconomic-related disparity in the use of eye care services within each zone. The weighted sum of these *N* CIs captures the fact that within the zone the poor may systematically have lesser or greater use of eye care services.

We also stratified zone-specific disparities based on Aboriginal status and urban or rural place of residence. Urban or rural residence was classified by the second digit of the postal code for home address in the Stakeholder Registry (36). The Forward Sortation Area (FSA) with the digit '0' was defined as rural place of residence and all other digits in the FSA were defined as urban place of residence. Aboriginal status was identified from the Alberta Health and Wellness (AHW) registry, which allows us to identify Status

Aboriginals (36). We used STATA 12 for Microsoft Windows for descriptive analyses and to calculate the CC and the RCI, as well as the geographic decomposition.

2.3. Results

Eye Care Services by Ophthalmologists

Descriptive statistics for the number of patients who had an eye care examination by an ophthalmologist over a 15-year period are presented in Table 2.1. The average annual rate of eye care services in 15 years was 31.7%, and during the study period, the rate of eye care services did not change dramatically. The highest rate of eye care services by ophthalmologists was in 2001, when approximately 40,000 (34.1%) of 116,235 diabetic individuals were assessed. The lowest rate of eye examination was in 1995, when only 22,647 (28.4%) of 79,743 diabetic individuals received eye care services.

Table 2.2 shows the distribution of eye care services by ophthalmologists across household income and deprivation indices quintiles in 2009, and the associated RCI, for the AHS zones and the province as a whole. Generally, the rates of eye care services provided by ophthalmologists for those living with higher income or with less material deprivation were higher than those for their counterparts. In contrast, diabetic patients from more socially deprived neighbourhoods used more eye care services during the same period.

Changes in socioeconomic related-disparities

Income-related disparities in the use of eye care services by ophthalmologists were observed over the 15 year-period (Table 2.3; Figure 2.1). The disparity has been in favour of higher income groups (i.e., pro-rich), suggesting that patients residing in higher income neighbourhoods were more likely to receive eye care services. The income-related RCI was relatively small in magnitude, and has not substantially changed over time; the RCI was 0.0309 in 1995, 0.0273 in 2002, and 0.0214 in 2009 (Figure 2.1).

Both MDI and SDI-related RCIs got attenuated over the period between 1995 and 2009; in both cases moving toward the line of equity (Table 2.3; Figure 2.1). It is noteworthy that while the MDI-related RCIs continuously showed “pro-rich” during the given period, the social deprivation-related RCI indicated “pro-poor” disparity, which suggests that individuals with diabetes residing in more socially deprived areas tended to use more eye care services compared with those residing in less socially deprived areas.

Socioeconomic disparities by Alberta Health Services (AHS) Zones

We observed considerable variation in the SES-related disparities in eye care services between AHS zones; the pattern of variation depended on the particular SES indicator. For example, in 2009 (Table 2.2), the North Zone had the greatest pro-rich disparity based on household income, followed by the South, then Central zones, with relatively little disparity in Edmonton or Calgary. While the overall disparity associated with MDI was larger than household income, between-zone variation was less obvious, although the Central and North displayed greater pro-rich disparities than Edmonton, South or Central zones (Table 2.2). On the other hand, for the SDI in 2009, the North zone displayed a small pro-rich disparity while all other zones displayed pro-poor disparities (Table 2.2).

Based on the geographic decomposition of the RCIs (Table 2.4) in the period 1995-2009, the "between zone" contributions to income-related RCIs were always greater than the "within zone" contribution. Similarly the MDI-related RCIs have decreased over time, but the variations among zones were always greater than variations within zones. In contrast to MDI-related RCIs, the contributions of "between zone" and "within zone" in SDI-related RCIs has changed over time, with relatively little "between zone" contribution and much more in the residual.

Plotting the trends in income-, MDI and SDI-related disparities in eye care services by AHS zones presents an interesting story (Figures 2.2-2.4). In terms of household income-related RCI, South zone has consistently had a larger magnitude of income-related RCIs among the five AHS zones. Calgary and Edmonton zones have consistently shown little household income-related disparities, while Central and North had continual increases in income-related RCIs over the 15-year period. In particular, a dramatic escalation in RCIs between 2004 and 2009 was observed in North zone (Figure 2.2).

For MDI-related RCIs, both Central and North zones had widening "pro-rich" disparities over a 15-year period, dramatically so for the North zone after 2004 (Figure 2.3). In contrast, the MDI-related RCIs for the remaining zones showed a constant decrease, in all cases moving toward the line of equity. With respect to SDI-related RCIs (Figure 2.4), North zone moved in a direction of "pro-rich" disparity. That is, individuals residing in less socially deprived neighbourhood were more likely to use eye care services. The remaining zones showed constant "pro-poor" disparities in the given period. Interestingly, there appeared to be a sharp widening in "pro-poor" disparity in Central zone between 1997 and 2000.

Because of the dramatic change in income- and MDI-related RCIs for the North zone, we further explored the trends in this zone, stratified by Aboriginal status and urban or rural residence. When stratified by Aboriginal status [Table S2.2-S2.6; Figure S2.1-S2.3], we see similar rates of eye care services over time. However, while the income-related RCI for the Aboriginal population remained relatively stable with little disparity over time, it increased substantially and almost linearly over time in the non-Aboriginal population in the North zone. MDI-related disparities increased in the non-Aboriginal population of the North zone after 2004, while in the Aboriginal population, MDI-related disparities (which were originally pro-rich) shifted to pro-poor after 2001. Thus, in recent years, it appears that Aboriginal people living in more materially deprived areas of the North zone were receiving more eye care services by ophthalmologists than Aboriginals living in less materially deprived areas of the North, while the opposite was true for the non-Aboriginal population. There appeared to be no difference in the widening pro-rich income-related disparities in the North zone between urban and rural dwellers, but in relation to the MDI related disparities, the greater increase of pro-rich disparity was primarily observed in the urban-dwelling population in the North zone [Table S2.7-S2.11; Figure S2.4-S2.6].

2.4. Discussion

Using provincial diabetes surveillance data, we demonstrated that socioeconomic disparities in the use of eye care services provided by ophthalmologists to diabetic patients have existed in Alberta over the past 15 years. In particular, individuals living in higher income neighborhoods and less materially deprived areas were more likely to receive eye care services, while, in contrast, diabetic patients living in more socially deprived areas were more likely to use the services. In general, however, the magnitudes of the disparities were relatively small. Furthermore, the MDI- and SDI-related disparities decreased over time. Interestingly, the trends in change over time of SES-related disparities varied considerably by zone, and depended on the particular SES indicator, as well as characteristics of sub-populations, namely Aboriginal status and urban versus rural residence.

The use of eye care services among diabetic patients may be influenced by a number of factors. Some of these factors include medical conditions and health behaviours at the individual level, but SES is also important. Despite Canada's universal health care system, which aims to minimize financial barriers to medically necessary healthcare, a vast literature has revealed that the use of health care services differs by socioeconomic condition (21, 39-41). For example, people with lower SES tend to use fewer specialist preventive services, but are more likely to see family physicians and use hospital services (26, 42, 43).

Given our study design, the decrease in disparities observed in our study may be related to increasing numbers of patients with a longer duration of diabetes in each of the years of follow-up. A longer duration of diabetes may foster patient understanding of the use of recommended care services and the rationale for the recommended care provided by their family doctor may lead patients to more active involvement in diabetes care in the primary care setting (44). In Ontario, the overall rate of undergoing a follow-up examination was only 19% within one year after the initial eye exam. However, the overall rate of a follow-up exam climbed to 55% at two years and 84% at four years after the initial assessment (17). Given the association between the duration of diabetes and compliance with recommended care, our finding could be interpreted by the fact that patients residing in less materially or more socially deprived areas receive more eye care services as their duration of diabetes increases.

With respect to income- and MDI-related disparities, our results are consistent with previous findings that higher SES is associated with increased the use of specialist services. Our findings with respect to trends of disparities in eye care services were broadly similar to those from a previous Canadian study (26) that also used RCIs to measure health care disparities in both family physician and specialist visits across Canadian provinces, demonstrating a “pro-rich” disparity for specialist visits. In particular, these authors reported a “pro-rich” inequity in specialist visits in Alberta, even after adjusting for number of specialist visits (26). It seems reasonable, then, to conclude that our findings show that lower neighbourhood income and more materially deprived residential areas are important conditions associated with the use of eye care services by ophthalmologists in Alberta. Our finding also suggest that the underuse of eye care services by people with lower economic status could cause further widen the gap in eye health outcomes, although the magnitude of disparities are relatively small (43). This potential implication could strengthen our concern that Canada’s universal health care system may reduce economic barrier to eye care services by eye care services by ophthalmologists, but does not completely eliminate it.

Unlike income or MDI-related disparities, SDI-related RCIs in the use of eye care services showed a "pro-poor" trend in disparities; that is, diabetic patients residing in more socially deprived area received more eye care services. The explanation for this opposing trend is not clear. One might argue that given the higher prevalence of diabetes in lower SES populations, there would also be greater prevalence of diabetic complications such as eye disease, and therefore more eye care services would be utilized. That explanation, however, is contradicted by the pro-rich disparities based on income and MDI. The difference, then, must be based on the different constructs of social deprivation relative to material deprivation, or the statistical construction of these two indices (28).

One Israeli study has attempted to explain the higher use of health care services in lower social condition groups. That study suggest that this finding could be explained by the fact that unemployed people, in particular retired individuals and individuals with co-morbid conditions, would be more likely to use specialist services (45). This suggests that, once patients leave the workforce, and have worse health outcomes, they would focus more time and attention on their health care, which is reflected by more services being performed. This explanation may help us understand the direction of disparity related to social deprivation RCIs found in our study.

Alternatively, the fact that there are more socially deprived areas in urban settings, where more ophthalmology services are available, could help explain the "pro-poor" direction of SDI-related RCIs. In our descriptive analysis of the distribution of SDI ranks across the province, lower SDI ranks were more concentrated in Edmonton and Calgary zones, but more than 80% of ophthalmologists offer eye care services in these two zones (data not shown). It is therefore plausible that a large number of individuals residing in more socially deprived neighbourhood in urban areas could easily access eye care services, and this may result in pro-poor disparities related to social deprivation RCIs. As a result, social deprivation may not be a strong predictor of the use of health care services. Due to the complexity of social capital, which links closely to the SDI, it has been suggested that not all components of social capital are related to use of health care services (46).

One possible explanation for the different direction of SDI-related RCI is the independency between material and social deprivation indices. Material and social deprivation index were constructed with principal component analysis (PCA), with application of a varimax rotation in order to improve readability and make these two factors independent (29). The scoring for using PCA forces the MDI and SDI to be uncorrelated. Still, the lack of correlation does not obviously explain the opposite relationship of MDI- and SDI-related RCI over time in the province as a whole. To understand the factors that might explain the observed "pro-poor" trend in SDI-related disparities, further research is required.

Uneven distribution of health care resource across the population has been a long-time public health concern in Canada (47, 48). Our results indicate regional disparities in the use of eye care services between AHS zones. For both income- and MDI-related RCIs, disparities in the use of eye care services *among* AHS zones were consistently larger than those *within* each zone. This could simply indicate an unequal distribution of eye care services resources across Alberta. Approximately 85% of ophthalmologists provide their services in urban areas such as Edmonton or Calgary as most Albertans live in these areas (49). This concentrated distribution of ophthalmologists in Edmonton and Calgary zones may be associated with regional disparities as diabetic patients living in those areas could access their eye care services more easily than those living in other AHS zones. Geographical disparities in the use of eye care services related to SDI-related RCIs were also observed during the same period, although the contribution of geography to between zone disparities became smaller than within zone disparities. Three AHS zones--- South, Calgary, and Edmonton---showed a relatively small magnitude of pro-poor disparities and moved closer to the line of equity.

The most notable finding was the change in income- and MDI-related disparities in the North zone, with increasingly pro-rich disparities after 2004. Given the rapid change in these disparities, it seems unlikely to be driven by specific demographic characteristics of the population. The pattern of change in disparities was not associated with Aboriginal status, but seemed to be more apparent in the non-Aboriginal urban-dwelling population in the North. One explanation for the rapid change in SES-related disparities in the North may be related to changes in policies or delivery of eye care services. For instance, the introduction of tele-ophthalmology services in Northern Alberta communities began in 1998 to provide recommended eye screening services for DR and eye care services: this was intended to address geographical barriers in access to ophthalmologist services. This introduction of the comprehensive tele-ophthalmology program may have inadvertently contributed to income- and MDI-related disparities in Northern Alberta communities (50).

Limitations

While the CC and RCI are widely used for quantifying the magnitude of socioeconomic inequality in health and health care, their use has well-known limitations that should make us cautious when interpreting the results of our study. Firstly, an obvious limitation of using the RCI as a measure of SES-related disparities is that the RCI does not take into account other individual-level factors associated with the use of eye care services such as clinical need, sex, age, and immigrant status (51). To mitigate this limitation, we used the Canadian deprivation index, which reflects various socioeconomic conditions including educational attainment, employment and social network.

Secondly, using income and the Canadian deprivation index at the sub-region level may limit our ability to understand income and deprivation at the individual level. Thus, SES measures at sub-region level could overlook variations in income and deprivation index among individuals in the same neighbourhood. Nevertheless, neighbourhood is an important factor affecting health outcomes and healthcare use in Canada as neighbourhoods are segregated by socioeconomic status. It, therefore, becomes crucial to understand the characteristic of neighbourhoods in tackling disparities in health care (52).

Thirdly, using provincial health care administrative data dose not allow us to assess the clinical need and appropriateness of the eye care services received or not received. In addition to this limitation in the classification of eye care services, provincial administrative database only included ophthalmology services, so patients who used optometry services were excluded from our analyses. As of 2007, eye examinations by optometrists for patients with diabetes have been covered by the provincial healthcare plan (13). Further examination of disparities in eye screening services should include information on services by both ophthalmologists and optometrists.

2.5. Conclusion

Our study suggests that household income-, MDI and SDI-related disparities in the use of eye care services were observed among diabetic patients living in Alberta. These disparities are not large, however, and trends over time suggest that they have been decreasing. However, while there appears to be very little SES-related disparities in the province overall, patterns of disparities in the use of eye care services among diabetic patients varied across AHS zones. Our findings suggest policy development at the provincial level may help to alleviate the observed disparities in eye care services among patients living with diabetes, particularly in the non-metro areas of the province. Nonetheless, further study is necessary to better understand the patterns and interpretation of socioeconomic disparities over time and geographical difference across AHS zones.

Tables and Figures

Table 2.1. Total number of diabetic patients who received eye care services by an ophthalmologist in a 15-year period

Year	Eye care services		Total	Rate of Service (%)
	Yes	NO		
1995	22,647	57,096	79,743	28.4
1996	25,265	58,110	83,375	30.3
1997	28,521	59,153	87,674	32.5
1998	30,909	61,924	92,833	33.3
1999	33,800	66,057	99,857	33.9
2000	35,858	71,813	107,671	33.3
2001	39,650	76,585	116,235	34.1
2002	42,286	83,143	125,429	33.7
2003	44,686	89,333	134,019	33.3
2004	47,351	96,402	143,753	32.9
2005	49,004	104,908	153,912	31.8
2006	50,549	114,247	164,796	30.7
2007	51,694	123,979	175,673	29.4
2008	53,814	132,154	185,968	28.9
2009	57,237	141,323	198,560	28.8

Table 2.2. Distribution of eye care services by household income and deprivation indices and AHS zones in 2009

Household Income[a]	South	Calgary	Central	Edmonton	North	Total
1st (Lower)	30.2%	32.9%	18.9%	25.5%	21.0%	26.3%
2nd	37.3%	32.8%	15.9%	28.2%	16.6%	27.7%
3rd	29.2%	33.3%	20.1%	25.2%	30.6%	30.8%
4th	52.9%	33.3%	26.9%	26.7%	35.1%	29.6%
5th(Higher)	35.7%	29.8%	18.7%	27.8%	24.4%	29.9%
RCI	0.0989	-0.0120	0.0637	0.0071	0.1164	0.0214
Material Deprivation[a]	South	Calgary	Central	Edmonton	North	Total
1st (More)	26.5%	26.0%	16.5%	24.9%	23.7%	26.0%
2nd	37.5%	28.6%	21.7%	28.0%	17.6%	28.6%
3rd	50.0%	28.3%	18.3%	23.5%	29.4%	28.3%
4th	35.7%	28.4%	21.0%	25.8%	35.1%	28.4%
5th (Less)	37.3%	33.2%	25.1%	31.7%	23.3%	33.2%
RCI	0.0309	0.0238	0.0832	0.0339	0.0796	0.0427
Social Deprivation[a]	South	Calgary	Central	Edmonton	North	Total
1st (More)	37.3%	34.6%	28.1%	27.1%	20.7%	30.5%
2nd	23.1%	35.0%	17.1%	26.6%	41.7%	32.7%
3rd	52.9%	31.5%	18.9%	27.8%	16.3%	27.1%
4th	31.7%	31.7%	21.1%	26.3%	20.9%	25.4%
5th (Less)	34.8%	29.2%	18.7%	24.1%	31.2%	28.4%
RCI	-0.0056	-0.0335	-0.0716	-0.0159	0.0167	-0.0278

a) Higher incomes and lesser deprivation are considered higher socioeconomic status

Table 2.3. SES-related Relative Concentration Indices in the use of eye care services, 1995-2009

	RCI(income)	*Change*	RCI(MDI)	*Change*	RCI(SDI)	*Change*
1995	**0.0309**		**0.0889**		**-0.0657**	
1996	**0.0364**	*0.005*	**0.0872**	*-0.002*	**-0.0557**	*0.010*
1997	**0.0272**	*-0.009*	**0.0766**	*-0.011*	**-0.0512**	*0.005*
1998	**0.0326**	*0.005*	**0.0772**	*0.001*	**-0.0484**	*0.003*
1999	**0.0310**	*-0.002*	**0.0720**	*-0.005*	**-0.0415**	*0.007*
2000	**0.0272**	*-0.004*	**0.0680**	*-0.004*	**-0.0477**	*-0.006*
2001	**0.0282**	*0.001*	**0.0627**	*-0.005*	**-0.0349**	*0.013*
2002	**0.0273**	*-0.001*	**0.0606**	*-0.002*	**-0.0360**	*-0.001*
2003	**0.0262**	*-0.001*	**0.0588**	*-0.002*	**-0.0347**	*0.001*
2004	**0.0261**	*0.000*	**0.0535**	*-0.005*	**-0.0319**	*0.003*
2005	**0.0229**	*-0.003*	**0.0530**	*-0.001*	**-0.0362**	*-0.004*
2006	**0.0245**	*0.002*	**0.0492**	*-0.004*	**-0.0322**	*0.004*
2007	**0.0300**	*0.006*	**0.0529**	*0.004*	**-0.0308**	*0.001*
2008	**0.0270**	*-0.003*	**0.0482**	*-0.005*	**-0.0253**	*0.006*
2009	**0.0214**	*-0.006*	**0.0427**	*-0.005*	**-0.0278**	*-0.003*

Table 2.4. Geographic decomposition of SES-related Concentration Indices by AHS zones

	Income				Material deprivation				Social deprivation			
	RCI(B)	**RCI(W)**	**Residual**	**Total RCI**	**RCI(B)**	**RCI(W)**	**Residual**	**Total RCI**	**RCI(B)**	**RCI(W)**	**Residual**	**Total RCI**
1995	0.0156	0.0053	0.0100	***0.0309***	0.0802	0.0130	-0.0043	***0.0889***	-0.0578	-0.0093	0.0014	***-0.0657***
1996	0.0261	0.0059	0.0043	***0.0364***	0.0841	0.0176	-0.0145	***0.0872***	-0.0567	-0.0024	0.0034	***-0.0557***
1997	0.0149	0.0057	0.0066	***0.0272***	0.0750	0.0168	-0.0152	***0.0766***	-0.0547	-0.0018	0.0053	***-0.0512***
1998	0.0108	0.0070	0.0149	***0.0326***	0.0686	0.0173	-0.0087	***0.0772***	-0.0561	-0.0015	0.0091	***-0.0484***
1999	0.0086	0.0065	0.0159	***0.0310***	0.0627	0.0163	-0.0069	***0.0720***	-0.0482	-0.0009	0.0076	***-0.0415***
2000	0.0008	0.0059	0.0205	***0.0272***	0.0561	0.0164	-0.0044	***0.0680***	-0.0420	-0.0025	-0.0032	***-0.0477***
2001	0.0095	0.0072	0.0116	***0.0282***	0.0580	0.0156	-0.0109	***0.0627***	-0.0412	0.0005	0.0058	***-0.0349***
2002	0.0184	0.0050	0.0039	***0.0273***	0.0623	0.0141	-0.0158	***0.0606***	-0.0407	-0.0005	0.0052	***-0.0360***
2003	0.0290	0.0041	-0.0069	***0.0262***	0.0670	0.0135	-0.0216	***0.0588***	-0.0359	-0.0008	0.0019	***-0.0347***
2004	0.0242	0.0043	-0.0025	***0.0261***	0.0562	0.0134	-0.0161	***0.0535***	-0.0235	-0.0011	-0.0073	***-0.0319***
2005	0.0223	0.0039	-0.0033	***0.0229***	0.0526	0.0133	-0.0130	***0.0530***	-0.0244	-0.0022	-0.0096	***-0.0362***
2006	0.0216	0.0039	-0.0010	***0.0245***	0.0446	0.0131	-0.0085	***0.0492***	-0.0139	-0.0017	-0.0167	***-0.0322***
2007	0.0249	0.0049	0.0002	***0.0300***	0.0419	0.0142	-0.0032	***0.0529***	-0.0099	-0.0018	-0.0190	***-0.0308***
2008	0.0250	0.0040	-0.0020	***0.0270***	0.0383	0.0139	-0.0040	***0.0482***	-0.0034	-0.0012	-0.0206	***-0.0253***
2009	0.0216	0.0027	-0.0029	***0.0214***	0.0328	0.0083	0.0017	***0.0427***	-0.0021	-0.0063	-0.0194	***-0.0278***

Figure 2.1. Relative Concentration Index in eye care services by ophthalmologists

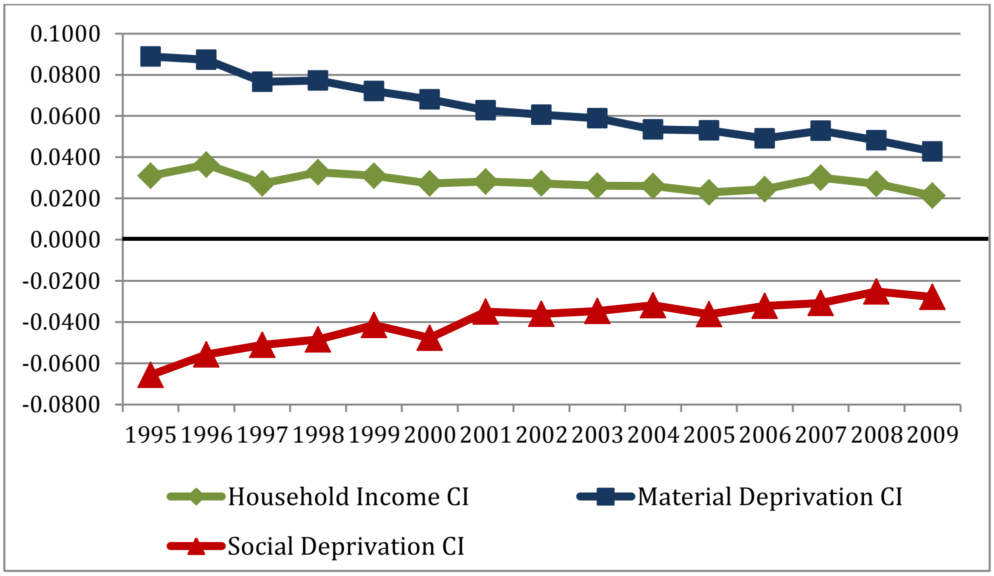


Figure 2.2. The trends of household income-related RCIs in eye care services by ophthalmologists

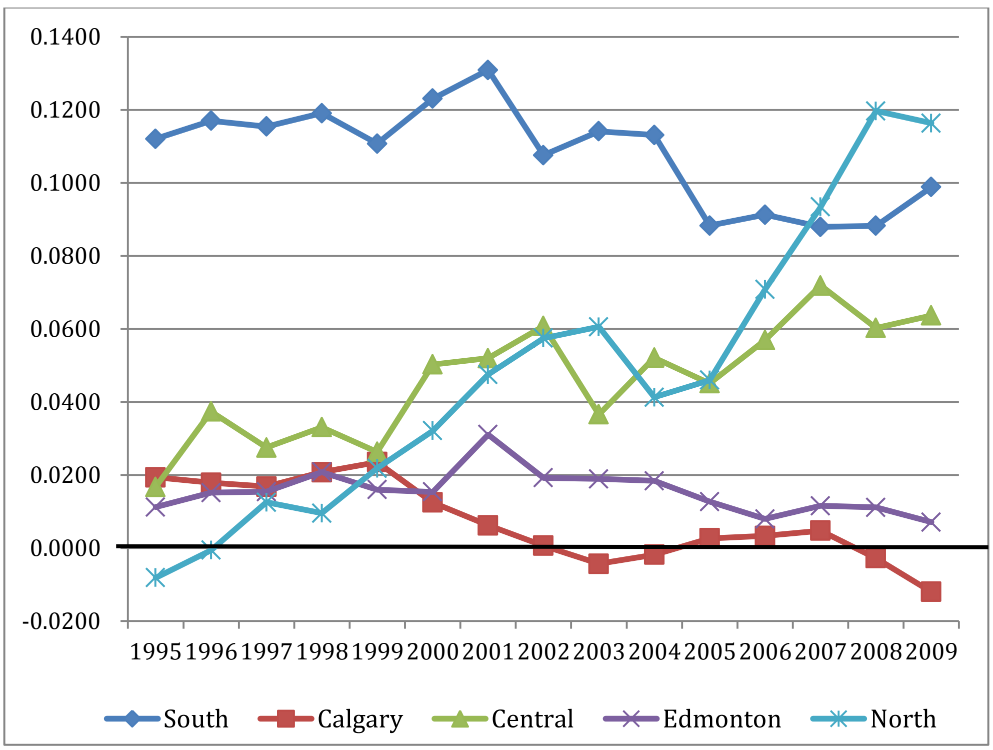


Figure 2.3. The trends of material deprivation index-related RCIs in eye care services by ophthalmologists

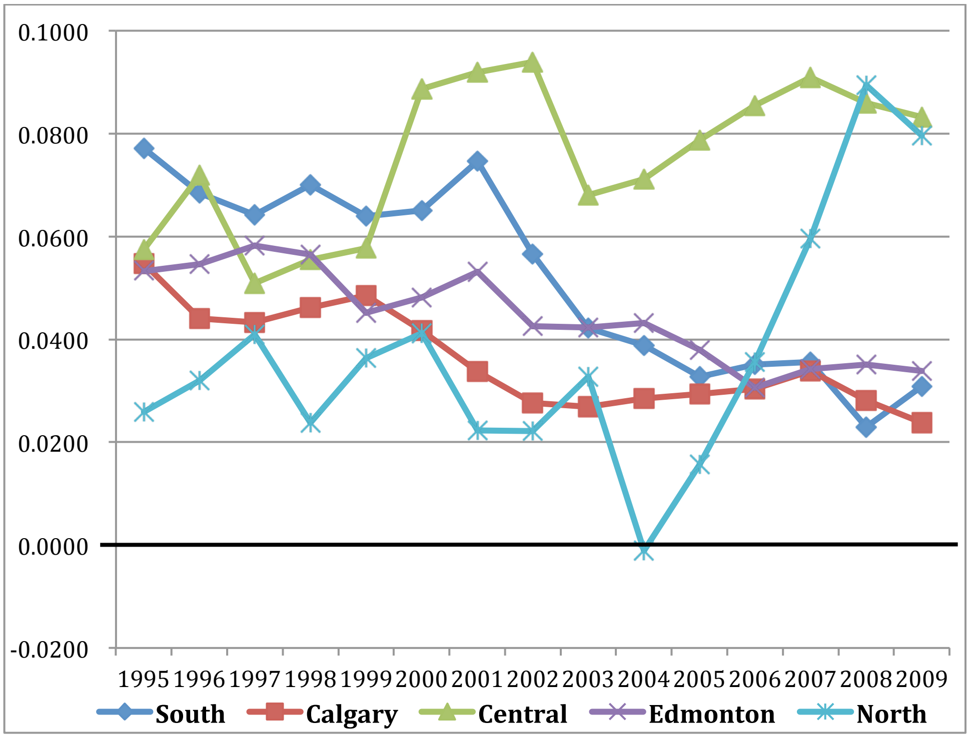
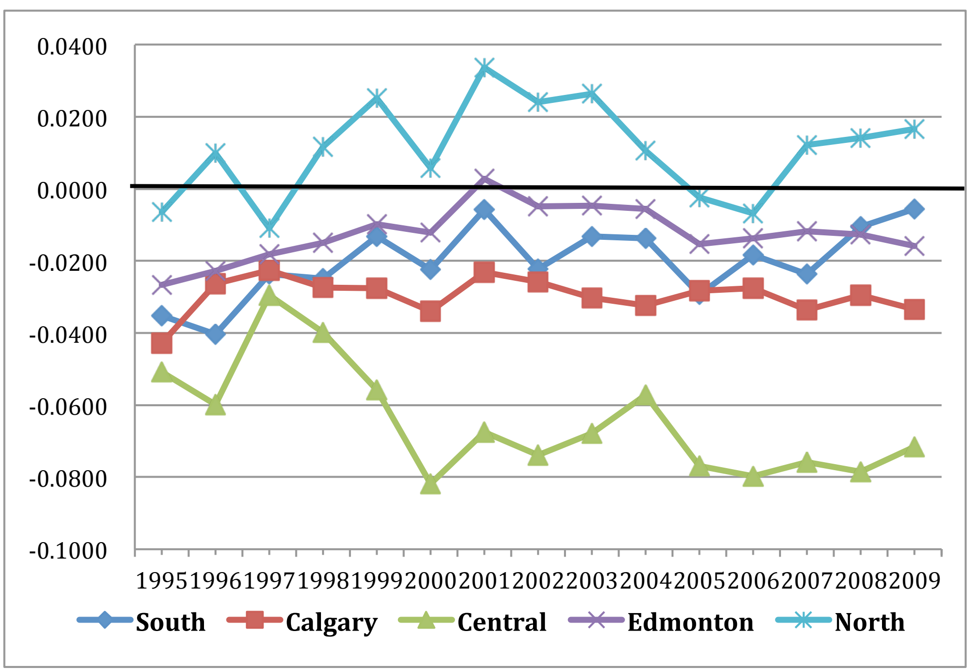


Figure 2.4. The trends of social deprivation index-related RCIs in eye care services by ophthalmologists



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Supplementary Tables and Figures

Table S2.1. Alberta physician claims data

Procedure	Code	Description
Retinal Laser Treatment (Retinal Photocoagulation)	28.5A	Focal and/or pan retinal photocoagulation
Vitrectomy Surgery	28.72A	Vitreous cavity washout
	28.72B	Total vitrectomy
	28.74A	Discission of vitreous/retinal adhesions
	28.74B	Stripping of premacular membrane, Associated vitrectomy and retinal encircling
Cataract Surgery	27.72	Insertion of intraocular lens prosthesis with cataract extraction, one-stage
Laser Treatment for Glaucoma	26.52 (1995-2004)	Laser peripheral iridotomy
	26.52A	Either laser peripheral iridotomy or argon laser trabeculoplasty or selective laser trabeculoplasty
End-Stage Glaucoma (Laser Treatment)	26.98B(2005-2009)	Diode laser cyclophotocoagulation (ciliary body ablation)
Glaucoma Surgery	26.2A (1995-2009)	Major glaucoma operation (trabeculectomy, EMS shunt)
	26.2B (1995-2009)	Ahmed shunt or Baerveldt shunt, with scleral patch graft
	26.25A (1998-2009)	Repeat trabeculectomy

Source: Alberta Diabetes Atlas 2011

Table S2.2. North zone – Distribution of eye care services by ophthalmologists for Aboriginal and non-Aboriginal people with diabetes, 1995-2009

Eye care service		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Aboriginal	Yes	144	167	204	217	252	272	363	502	552	684	687	702	685	653	732
	No	942	1,009	1,063	1,137	1,243	1,370	1,435	1,465	1,602	1,591	1,739	1,870	2,050	2,220	2,287
	%	13.3	14.2	16.1	16.0	16.9	16.6	20.2	25.5	25.6	30.1	28.3	27.3	25.0	22.7	24.2
Non-Aboriginal	Yes	1,309	1,559	1,725	1,943	2,211	2,315	2,676	2,865	3,208	3,496	3,718	4,042	4,353	4,698	5,100
	No	7,142	7,281	7,494	7,778	8,207	8,809	9,335	10,135	10,859	11,499	12,269	12,888	13,565	14,195	15,148
	%	15.5	17.6	18.7	20.0	21.2	20.8	22.3	22.0	22.8	23.3	23.3	23.9	24.3	24.9	25.2

Table S2.3. North zone – Distribution of eye care services in Aboriginal people with diabetes by income quintile

Income Quintile	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1st (Lower)	12.0	12.9	15.5	12.5	13.8	16.9	19.0	27.9	26.5	31.1	30.2	33.9	31.7	28.7	28.8
2nd	14.8	11.9	15.5	18.9	16.4	14.2	18.3	18.4	19.3	26.7	19.8	20.5	18.0	15.4	19.9
3rd	14.4	15.0	16.5	18.3	17.4	16.6	18.4	23.7	28.3	31.4	32.7	27.0	22.7	19.8	19.3
4th	18.0	21.7	21.5	19.2	24.2	25.3	24.8	28.5	24.9	25.9	27.8	25.3	22.6	22.9	25.4
5th (Higher)	9.4	12.7	14.0	13.4	16.8	14.1	24.1	30.6	27.8	33.7	28.7	27.0	29.4	26.7	29.0
RCI	**-0.024**	**0.047**	**0.014**	**0.015**	**0.057**	**0.003**	**0.046**	**0.029**	**0.017**	**0.014**	**0.011**	**-0.042**	**-0.013**	**-0.007**	**0.010**

Table S2.4. North zone- Distribution of eye care services in non-Aboriginals by income quintile

Income Quintile	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1st (Lower)	15.0	17.8	18.5	18.3	19.9	19.0	19.8	20.0	20.4	21.3	21.3	20.6	20.5	20.2	19.2
2nd	16.0	17.0	18.6	20.9	20.9	19.4	19.4	16.8	16.7	18.2	17.7	16.7	16.5	15.2	14.4
3rd	15.7	19.3	19.1	20.8	24.1	23.0	28.0	29.3	31.5	31.0	31.1	29.9	29.6	29.8	28.2
4th	16.6	19.0	20.5	22.1	22.9	24.6	27.6	28.5	30.8	31.2	31.3	33.2	33.4	35.5	42.1
5th (higher)	10.7	12.4	12.4	13.3	16.4	14.9	12.6	13.2	11.4	10.5	10.7	16.0	20.5	23.1	23.5
RCI	**-0.007**	**-0.005**	**0.006**	**0.010**	**0.019**	**0.035**	**0.042**	**0.064**	**0.071**	**0.055**	**0.060**	**0.091**	**0.109**	**0.135**	**0.130**

Table S2.5. North zone- Distribution of eye care services in Aboriginals by MDI quintile

MDI Quintile	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1st (More)	11.5	12.1	14.4	11.8	14.8	16.4	21.7	30.7	28.5	34.1	32.2	33.2	33.0	29.5	31.1
2nd	14.8	11.9	15.5	18.9	16.4	14.2	18.3	18.4	19.3	26.7	19.8	20.5	18.0	15.4	19.9
3rd	18.2	12.8	12.9	18.9	20.4	17.1	19.1	26.1	23.5	25.8	25.6	29.8	21.6	20.0	25.2
4th	14.9	19.4	16.5	35.3	17.4	24.4	18.4	23.7	28.2	31.3	32.7	27.0	22.6	20.6	19.3
5th (Less)	11.0	19.4	20.5	11.7	19.5	17.5	23.1	25.5	23.4	25.1	19.1	21.8	23.0	22.2	24.4
RCI	**0.002**	**0.088**	**0.073**	**0.064**	**0.049**	**0.026**	**-0.023**	**-0.055**	**-0.028**	**-0.044**	**-0.029**	**-0.069**	**-0.079**	**-0.075**	**-0.079**

Table S2.6. North zone- Distribution of eye care services in non- Aboriginals by MDI quintile

MDI Quintile	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1st (More)	13.6	15.9	16.3	18.3	18.9	19.4	23.3	22.6	22.9	24.4	24.0	24.1	24.1	23.5	24.6
2nd	16.2	19.7	20.0	21.0	22.0	19.7	18.9	17.2	17.7	18.7	18.3	17.0	16.5	15.5	14.9
3rd	15.9	17.6	18.3	21.0	23.4	22.0	25.0	26.3	28.4	27.7	26.6	26.7	26.8	28.0	26.9
4th	17.4	19.5	21.7	22.3	23.2	25.0	28.0	29.2	31.1	31.4	31.8	33.2	33.4	35.5	42.1
5th (Less)	10.9	12.8	11.8	12.0	16.0	14.6	11.6	12.5	10.8	9.4	10.5	15.6	20.5	22.9	23.4
RCI	**0.023**	**0.018**	**0.026**	**0.014**	**0.028**	**0.035**	**0.018**	**0.042**	**0.049**	**0.025**	**0.039**	**0.062**	**0.083**	**0.109**	**0.101**

Table S2.7. North zone – Distribution of eye care services by ophthalmologists for urban and rural dwelling people with diabetes, 1995-2009

Eye care Service		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Urban	Yes	436	543	731	812	973	1,036	1,202	1,289	1,468	1,567	1,695	1,917	2,184	2,421	2,660
	No	2,333	2,430	2,977	3,255	3,516	3,878	4,217	4,673	5,085	5,531	5,982	6,266	6,647	6,956	7,687
	%	15.7	18.3	19.7	20.0	21.7	21.1	22.2	21.6	22.4	22.1	22.1	23.4	24.7	25.8	25.7
Rural	Yes	1,017	1,183	1,198	1,348	1,490	1,551	1,837	2,078	2,292	2,613	2,710	2,827	2,854	2,930	3,172
	No	5,751	5,860	5,580	5,660	5,934	6,301	6,553	6,927	7,376	7,559	8,026	8,492	8,968	9,459	9,748
	%	15.0	16.8	17.7	19.2	20.1	19.8	21.9	23.1	23.7	25.7	25.2	25.0	24.1	23.7	24.6

Table S2.8. North zone- Distribution of eye care services in urban dwellers by income quintile

Income Quintile	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1st (Lower)	14.7	19.2	20.5	20.2	20.6	18.7	19.7	17.9	18.2	17.5	16.9	17.2	16.8	16.0	15.0
2nd	16.0	21.4	21.7	23.4	25.2	22.5	23.7	20.3	21.1	20.8	20.6	18.3	18.6	16.1	13.1
3rd	15.6	15.3	17.0	17.1	16.5	18.8	18.5	16.4	14.8	16.6	15.6	21.4	20.0	23.4	24.7
4th	14.8	24.8	27.6	27.4	30.6	30.3	36.3	39.4	44.5	43.3	43.8	41.0	42.4	44.4	43.1
5th (Higher)	15.4	12.7	11.9	11.8	15.5	14.3	11.8	12.6	11.3	10.0	10.5	15.4	20.8	22.5	23.3
RCI	**-0.028**	**-0.034**	**-0.052**	**-0.050**	**-0.011**	**0.003**	**0.000**	**0.032**	**0.032**	**0.018**	**0.031**	**0.063**	**0.095**	**0.120**	**0.118**

Table S2.9. North zone- Distribution of eye care services in rural dwellers by income quintile

Income Quintile	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1st (Lower)	14.5	17.0	17.1	16.9	18.3	18.8	19.9	22.3	22.4	24.6	24.8	24.8	24.1	23.4	23.3
2nd	16.1	16.0	16.4	18.4	18.1	18.0	20.4	18.9	18.5	20.1	18.7	17.1	17.8	16.5	19.0
3rd	15.6	16.1	17.6	20.1	20.0	18.0	17.8	17.5	18.8	22.9	21.8	20.6	18.2	16.8	17.1
4th	15.7	19.1	19.2	20.6	24.1	23.0	26.8	29.1	31.1	30.3	30.7	31.0	30.5	31.1	32.6
5th (Higher)	13.8	16.5	18.5	21.2	20.8	21.9	26.8	29.3	29.6	31.5	30.7	31.5	30.7	31.1	32.1
RCI	**-0.010**	**-0.009**	**0.018**	**0.038**	**0.038**	**0.040**	**0.069**	**0.079**	**0.085**	**0.069**	**0.073**	**0.086**	**0.083**	**0.095**	**0.102**

Table S2.10. North zone- Distribution of eye care services in urban dwellers by MDI quintile

MDI Quintile	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1st (More)	13.3	18.8	19.4	20.2	21.0	19.7	22.5	20.5	21.0	20.2	19.9	19.6	18.9	17.5	17.4
2nd	16.3	20.8	24.8	24.6	26.1	21.4	19.5	16.2	16.6	16.2	16.3	14.3	14.8	13.7	11.6
3rd	15.7	15.7	17.1	17.3	16.8	19.3	18.8	16.5	15.2	17.2	15.7	21.4	20.4	23.4	24.6
4th	15.7	24.8	27.6	27.4	30.6	30.3	36.3	39.4	44.5	43.3	43.8	41.0	42.4	44.4	43.1
5th (Less)	15.6	12.7	11.9	11.8	15.4	14.3	11.8	12.6	11.2	10.0	10.5	15.4	20.8	22.6	23.2
RCI	**-0.023**	**-0.034**	**-0.036**	**-0.051**	**-0.007**	**-0.003**	**-0.018**	**0.017**	**0.016**	**0.006**	**0.016**	**0.050**	**0.085**	**0.114**	**0.108**

Table S2.11. North zone- Distribution of eye care services in rural dwellers by MDI quintile

MDI Quintile	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1st (More)	13.3	14.5	15.7	16.1	17.1	17.3	20.8	22.5	21.7	25.3	23.4	23.8	23.7	22.7	24.4
2nd	16.6	19.2	18.6	21.0	22.1	21.7	22.7	22.4	24.4	25.1	25.8	24.5	23.5	23.2	22.1
3rd	15.8	16.0	17.8	20.0	19.8	17.9	17.3	17.8	19.1	22.2	22.1	20.3	17.7	16.3	16.6
4th	15.7	18.3	18.4	21.2	23.4	21.9	25.0	27.0	28.2	27.7	26.9	26.6	26.2	27.4	29.1
5th (Less)	14.4	18.9	20.7	21.4	21.7	24.6	27.9	30.1	31.0	31.0	32.9	34.5	33.9	33.9	35.2
RCI	**0.039**	**0.046**	**0.048**	**0.060**	**0.056**	**0.060**	**0.038**	**0.032**	**0.049**	**0.007**	**0.038**	**0.034**	**0.028**	**0.040**	**0.040**

Figure S2.1. Proportion of Aboriginals and non- Aboriginals in North Zone with eye care services by ophthalmologists

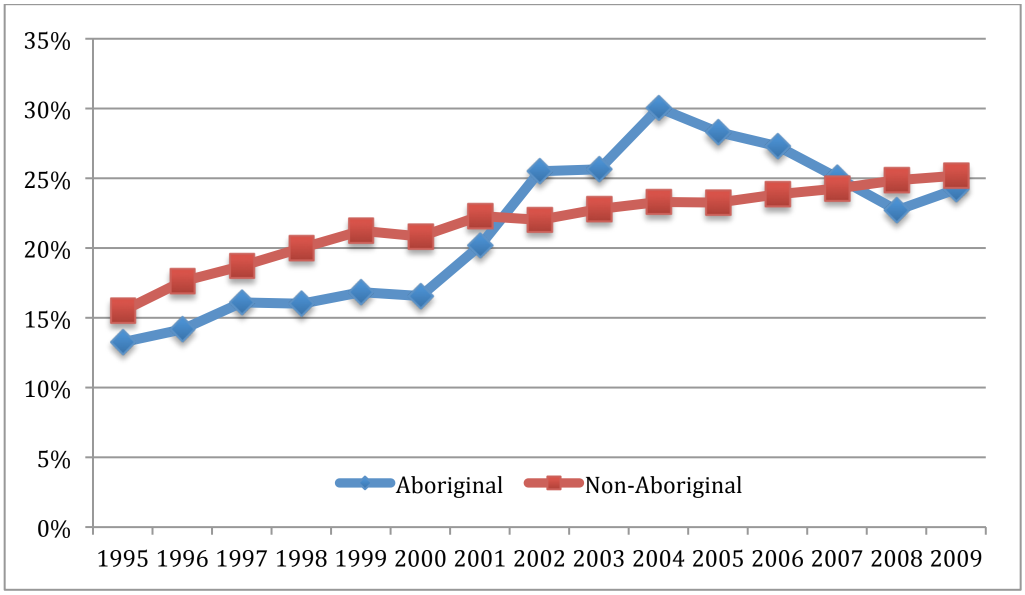


Figure S2.2. Income-related RCI by Aboriginal status in North Zone

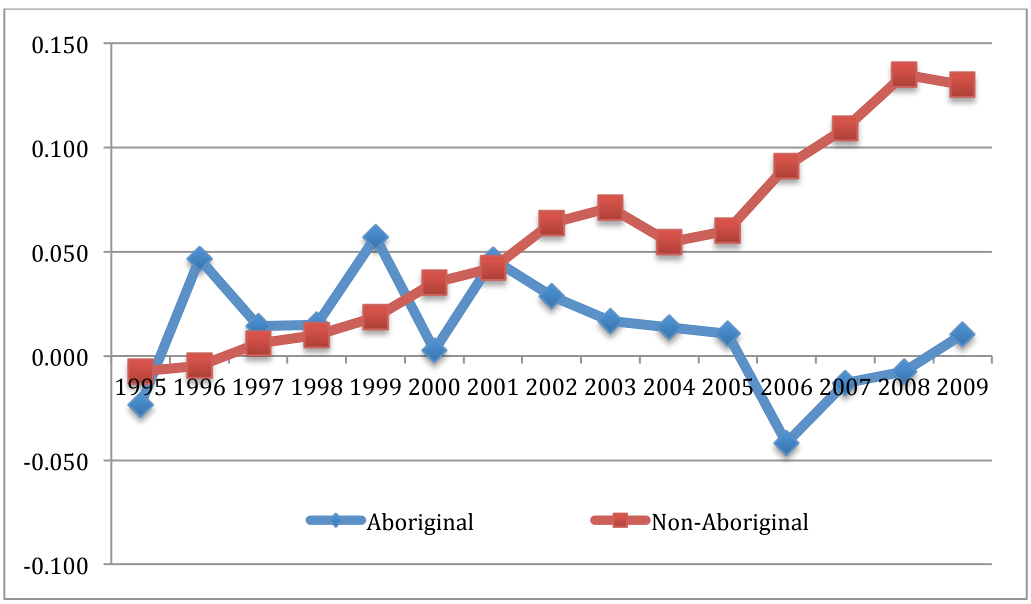


Figure S2.3. MDI-related RCI by Aboriginal status in North Zone

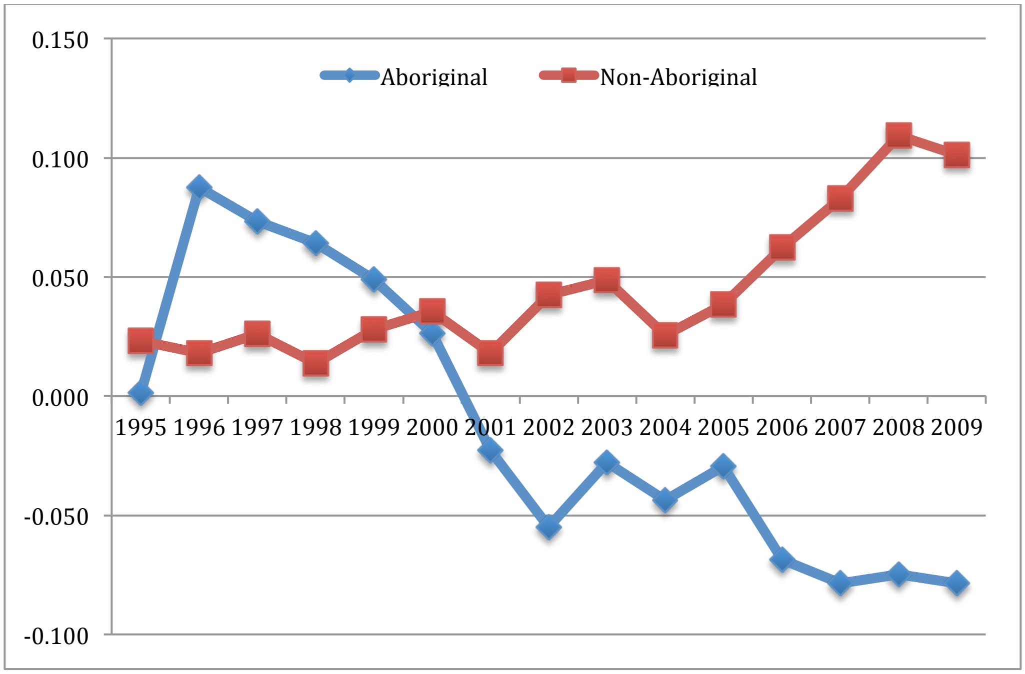


Figure S2.4. Proportion of urban and rural dwellers in North Zone with eye care services by an ophthalmologist

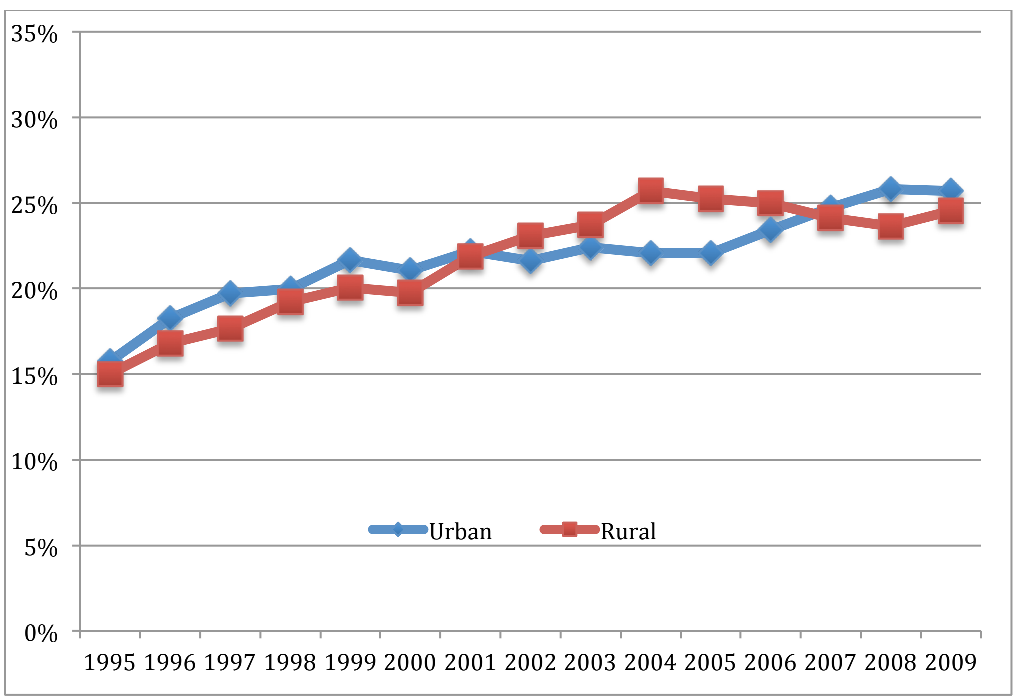


Figure S2.5. Income-related RCI by Urban and rural in North zone

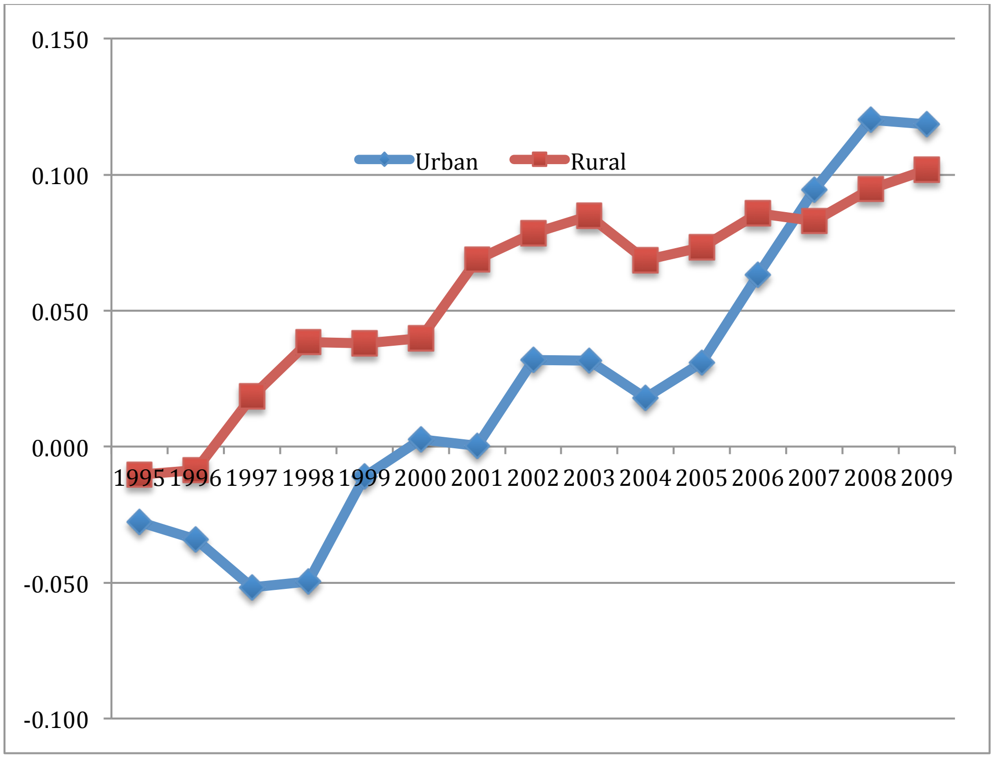
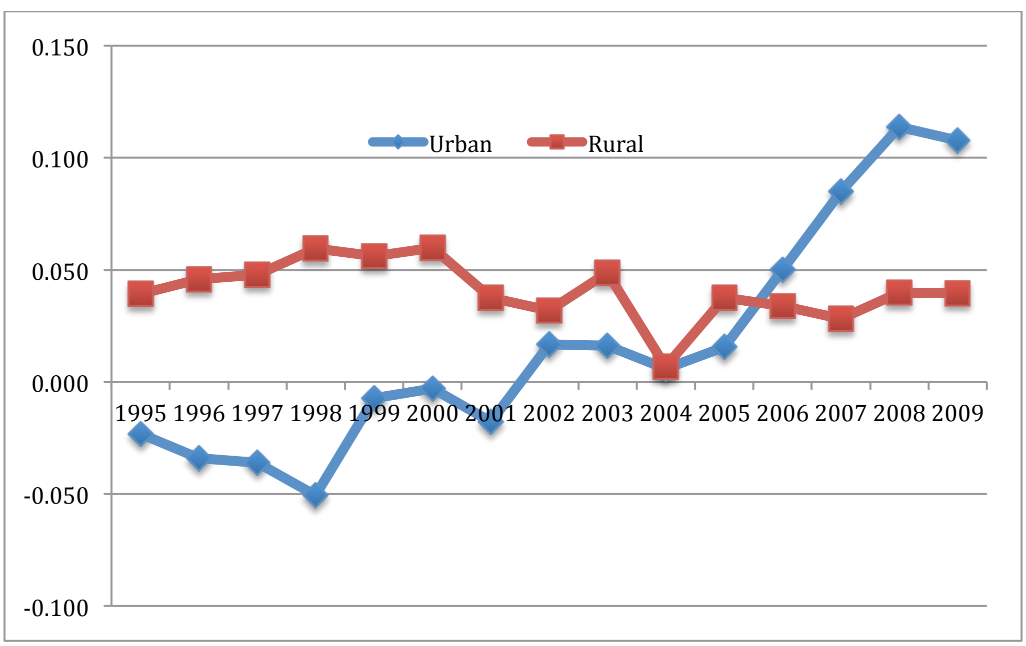


Figure S2.6. MDI-related RCI by urban and rural in North Zone



Chapter 3. Determinants of Socioeconomic Inequities in the Use of Eye Care Services among Diabetic Patients in Alberta, Canada 1995-2009

Abstract

Diabetic retinopathy (DR) is a serious life-threatening complication in diabetic patients. The Canadian Diabetes Association clinical guidelines recommend an annual dilated eye examination by an eye care specialist for timely detection and effective prevention. Previous studies have suggested that socioeconomic status (SES) is associated with use of the recommended eye care services. However, Canadian evidence on the factors associated with SES-related disparities in the use of eye screening services among diabetic patients is limited. Therefore, the aim of this study was to assess SES-related disparities in the use of eye care services among diabetic patients in Alberta, Canada. We applied the econometric techniques of Relative Concentration Index (RCI), and used regression-based decomposition analysis to identify major contributors to SES-related disparities. Horizontal inequity index (HI), which represents equal access for equal need, was calculated based on decomposition methods by quantifying contributions of need and non-need factors. SES was represented by 3 different measures: census-based median household income, and material (MDI) and social deprivation (SDI) indices. This study used data from the Alberta Diabetes Surveillance System (ADSS) 1995-2009: a total of 1,949,498 diabetic patients over a 15-year period were included in the analyses. Eye care service was defined in this study as any visit to an ophthalmologist, based on the medical services claims database. We found horizontal inequity among diabetic patients in the use of eye care services by an ophthalmologist but these differed depending on the specific SES indicator. Income and material deprivation-related HIs have been in favour of richer groups (i.e., pro-rich), however, the social deprivation-related HIs have been in favour of poorer groups (i.e. socially deprived diabetic patients tended to use more eye screening

services than those who were less socially deprived). In addition, the study found that the MDI and place of residence (urban/ rural) were important contributors to the observed "pro-rich" income- and MDI-related RCIs. The observed SDI-related inequity was explained by SDI itself. The findings imply that economic- and social-related resources generate different directions of disparities in the use of eye screening services and also suggest the need for developing health policy to alleviate different determinants of SES-related disparities in the use of eye screening services in diabetic patients in Alberta.

3.1. Introduction

Diabetic retinopathy (DR) is a major cause of visual impairment that ultimately impedes daily activities and decreases quality of life (1-5). The development of DR is closely associated with the duration of diabetes: as the diabetic condition develops, the risk of visual impairment increases (1). Approximately 78% of patients with a 15-year duration of diabetes have DR, which indicates higher prevalence of DR compared to diabetic patients with 5-year duration (6). Visual impairment caused by DR is preventable and manageable if diagnosed at the early stage of its course (1, 7). Thus, diabetic patients with sight-threatening DR should receive eye examinations by either an ophthalmologist or a retinal specialist as part of diabetic eye complications management (7). For early detection and timely treatment, it is recommended that all diagnosed diabetic patients receive periodic eye care services by a health professional (7).

Despite well-documented and comprehensive clinical guidelines, there is underuse of the recommended eye care services among diabetic patients in Canada. One study of five provinces and one territory reported that only 68% of patients with diabetes had received the recommended level of eye examination services (8). In Alberta, only 49% of patients received an eye examination by an ophthalmologist within three years of being diagnosed with diabetes and the rate of eye examinations has decreased over previous years (3).

Equal access to health care is enshrined in the Canada Health Act (CHA), clearly indicating that equity in health care is a main goal of the legislation and that no one should be discriminated against on the basis of their age, sex, income, or educational attainment (9, 10). The CHA states that medically necessary services for maintaining health, preventing disease or diagnosing or treating an illness should be provided by provincial health care plan to all residents without barriers, eye care services for diabetic patients fall under medically necessary services (7, 10). Nonetheless, a growing body of literature has identified several barriers to eye care service access in the general Canadian population (11, 12). These include limited resources to meet the demand for eye care services, variations in health care coverage between provinces, and lack of collaborative services between health care providers (11). While differences in health care utilization amongst patients may be driven by clinical need, differences that are driven by non-need factors, such as socioeconomic status (SES) or geography represent inequities, are not simply disparities. The presence of disparities that are drive by non-need factors is referred to as horizontal inequity index (HI), the amelioration of whichis a prominent health care objective in all OECD countries (13).

Notwithstanding the recognized importance of diabetic patients receiving eye screening services, inequities in such use has been found (14, 15). In particular, lower SES is consistently associated with underutilization of eye care services, a finding observed internationally regardless of the type of health care system (16-21). Despite the growing interest in health inequities in Canada, evidence on inequities in eye care services in the diabetic population is scarce. Given the increase in the number of low-socioeconomic families during the past decade and significant clustering of low SES by neighbourhood (22, 23), it is plausible that SES might play a pivotal role in increasing inequity in utilization of eye care services in patients with diabetes. It is crucial to understand and to quantify contributors of inequities in eye care services in order to suggest policy options.

We previously reported the existence of SES-related disparities in eye care services for Albertans living with diabetes (24), including variations in disparities by geography in the province. The objectives of the study were to identify socio-demographic determinants of SES-related disparitiesin the use of eye care services in patients with diabetes living in Alberta; to quantify the contribution of each determinant to the observed disparities; and to determine whether these might be interpreted as inequities.

3.2. Methods

We used data from the Alberta Diabetes Surveillance System (ADSS) from 1995 to 2009. The ADSS is the provincial diabetes surveillance system, which provides information on the incidence, prevalence, and mortality of diabetes and its complications in Alberta, Canada (25, 26). The ADSS datasets are created by linking and de-identifying data from several Alberta Health and Wellness (AHW) databases, including discharge abstract databases, the physician claims databases, the ambulatory care classification system, and the population registry (25). The ADSS datasets include all diabetic patients, diagnosed by physicians and covered by the provincial health care system from 1995-2009. The case definition to identify diabetic patients requires that an individual must have one hospitalization with an International Classification of Disease, 9th revision (ICD-9) code of 250, selected from all available diagnostic codes from the hospital discharge abstract for years 1995-2001, or equivalent ICD-10 codes (E10-E14) for the years after 2001-2002, or two physician claims with an ICD-9 code of 250 within 2 years, selected from any of the three available diagnostic codes from the physician claims database (26). Women with gestational diabetes were excluded from these cases (26). In this study, we included only diabetic patients over age 20, and individuals whose postal code were linkable to a specific neighbourhood.

We used three different SES indicators: census-based median household income, and the Canadian material and social deprivation indices (27). The median household income was obtained from 2006 Canadian census data and linked to the ADSS datasets using Alberta's 70 sub-region levels. The Canadian deprivation index, which consists of separate indices of material and social deprivation, were created based on 2006 Canadian census data. Both material deprivation index (MDI) and social deprivation index (SDI) were linked to the ADSS datasets at the sub-region level. The Canadian deprivation index was developed to measure multiple dimensions of SES and is widely used as a standard measurement of SES (27). MDI is a composition of educational attainment, employment status and income level. SDI includes the prevalence of single-parent families as well as those people living alone, and those who are separated, divorced or widowed.

The use of eye care services by ophthalmologists after a patient's initial diagnosis of diabetes was measured by all contacts with ophthalmologists in each year from1995 to 2009. This would include any type of services or procedure provided by ophthalmologists and claimed for reimbursement by Alberta Health and Wellness [Table S3.1]. In Alberta, optometrist services were not fully covered by the provincial health care plan during this time period and were therefore not included in the physician claims database.

To quantify the contribution of an individual determinant to the SES-related Relative Concentration Index (RCI), we first calculated the RCIs, and 95% confidence intervals, from 1995 to 2009 based on household income, material and social deprivation indices.The RCI is commonly used as a standard measurement tool for socioeconomic-related inequality in the field of health economics and policy (28, 29). The RCI is derived from a concentration curve, where the individuals are ranked by socioeconomic status, and the cumulative percentage of each group is plotted against the cumulative share of total health care use (29). We then calculated the RCIs for the population,stratified by age, sex, Aboriginal status, place of residence (urban/rural), and duration of diabetes.

After obtaining the RCIs for the 15-year period, we applied the decomposition method to assess the major contributors to socioeconomic-related RCIs. The decomposition of the RCI was proposed by Wagstaff et al. (30). The basic idea of decomposition is that disparities in an outcome variable reflect, at a minimum, disparities in various associated factors (explanatory variables) (30, 31). To apply the decomposition method, age, sex, duration of diabetes were included as “need” factors (i.e., risk, and thus use, would be expected to increase with ‘need’ factors), while Aboriginal status, place of residence and Alberta Health Services (AHS) zones, were included as non-need factors in our analytic model.In decomposition analysis, the non-need factors are usually considered as violations of horizontal equity principle (32). Age-sex interactions were generated based on the identified age-sex related risks of diabetic eye disease (33). The other explanatory variables included in our analytic models have been well documented as determinants of health and health care in Canadian literature (23, 34, 35). The decomposition of the RCI was computed by the following steps. Assuming that the outcome variable for eye care services by an ophthalmologistis linked to *k* determinants through a linear regression, it is possible to decompose the RCI by those *k* determinants as follows:

$$RCI = \sum_{K} (\beta_K x_{K/} \mu) C_K + \frac{GC_\varepsilon}{\mu} = C_{\hat{y}} + GC_\varepsilon/\mu$$

Where μ is the mean of the proportion of eye care services by an ophthalmologist, β_k is the regression coefficients for the explanatory variables, x_k is the mean of individual explanatory variables, C_k is householdincome, MDI, or SDI-related RCI and GC_ε is the generalized concentration index for the error term.

The decomposition analysis was conducted using the following steps:

(1) the outcome variable (i.e., eye care services by an ophthalmologist) was regressed against the explanatory variables (i.e., age, sex, Aboriginal status, AHS zone and duration of diabetes) using a probit model. This provides the marginal effects of the explanatory variables (i.e., β_k).

(2) the means of the outcome variable and each of the explanatory variables (i.e., x_k) were calculated.

(3) the RCI for the outcome variable and the explanatory variables (i.e., *C* and C_k) were calculated, using the equation for RCI – $C = \frac{2}{N\mu}\sum_{t=1}^{n} h_i r_i - 1 - \frac{1}{N}$as well as the generalized RCI of the error term (i.e., *GC*).

The contribution of each determinant to socioeconomic-related RCI in eye care services was quantified as follows: (1) The absolute contribution of each determinant was calculated by multiplying its outcome elasticity ($\beta_K x_k/\mu$) with respect to each determinant and the relevant RCI of each determinant, (2) The percentage contribution of each determinant was calculated by dividing its absolute contribution by the RCI of the outcome variable (36, 37). Positive contribution of each determinant indicates that the determinant is associated with both socioeconomic status and outcome variables. In other words, positive contribution of the determinant can be interpreted that the observed disparities can be *x* % reduced if the determinant is distributed equally across socioeconomic groups.

In addition to decomposing the RCIs, we calculated the horizontal inequity index (HI), which can be computed as the RCI minus the sum of the absolute contributions of all 'need' factor variables as Wagstaff, et al. proposed (29). HI represents the egalitarian principle of equal treatment or access for equal need, irrespective of characteristic such as income, place of residence, etc. A positive (negative) value of HI indicates horizontal inequity favouring the better-off (worse-off). A zero value of HI means no horizontal inequity (i.e., eye care is proportionally distributed by need across income, MDI, and SDI distribution). In decomposition analysis, need factor for eye care services were represented through age, sex, and duration of diabetes, as these variables reflect individual's health care needs (32). All the RCIs, HIs, and decomposition of the RCIs were estimated using STATA 12 for Microsoft Windows.

3.3. Results

Concentration Indices for each determinant applying different socioeconomic measures

Table 3.1 presents income-related RCIs for the diabetic population stratified by sex, age, place of residence (i.e., urban and rural), Aboriginal status, and duration of diabetes during the follow-up period. These RCIs summarize the distribution of eye care services by the quintiles of SES indicator for each of the explanatory variables [Table S3.2-S3.4]. In both young (less than 65 years of age) and old (more than 65 years of age) groups, "pro-rich" disparities in eye care services were observed. The income-related RCIs decreased marginally over time, and similarly for both young and old groups. The magnitude of income-related RCIs for sex and duration of diabetes did not change substantially over time. It is noteworthy that while “pro-rich”income-related disparities in urban areas decreased over time, “pro-rich” disparities in rural areas increased during the same period. The “pro-rich” pattern of RCIs related to non-Aboriginals dropped towards the null (i.e., no disparity), whiledisparities in Aboriginal population increased, starting from a “pro-poor” disparity in 1995, becoming increasingly “pro-rich”from 2001 and thereafter.

Similar to income-related RCIs, MDI-related RCIs have decreasedduring the past 15 years in both male and female, young and old, and shorter and longer duration of diabetes (Table 3.2). While MDI-related RCIs decreased for both urban and rural areas over time, the decrease was larger, and became closer to equity in rural compared to urban areas. Aboriginal status was associated with a change from “pro-rich” to increasingly “pro-poor”disparities after 2002. In contrast, a constant decrease in “pro-rich” disparities in non-Aboriginal groups was found over the same time period.

While the income and MDI- related disparities were generally pro-rich, SDI-related RCIs were generally “pro-poor” (Table 3.3). This was seen for male and female, younger and older ages, and regardless of diabetes duration. Different patterns were observed, however, between urban and rural and Aboriginal and non-Aboriginal groups. The urban area group had consistently “pro-poor” disparities while the rural area group had “pro-rich” disparities, although over time both pro-poor and pro-rich disparities were reduced somewhat. The non-Aboriginal population had “pro-poor” disparities, suggesting that individuals living in more socially deprived neighbourhoods were more likely to receive eye care services, but these disparities decreased over time. In contrast, the SDI-related RCIs in Aboriginal diabetic individuals were initially pro-poor, but became "pro-rich" after 1999, suggesting that the eye care services were increasingly concentrated in Aboriginals living in less socially deprived areas.

Horizontal inequity index (HI)

Over the period from 1995 to 2009, socioeconomic-related horizontal inequitieswere observed but steadily decreased (Table 3.4-3.6; Figure 3.1). Both income- and MDI-related HIs were consistently in favour of the rich, suggesting that individuals living in higher income or less materially deprived neighbourhoods were inclined to use more eye care services. In contrast, SDI-related HIs were consistently in favour of the poor, suggesting that those living in more socially deprived neighbourhoods tended to use more eye care services. In particular, we found that contributions of non-need factors such as an individual's SES were always larger than those of need factors in income-, MDI-, and SDI-related RCIs. As a result, our finding suggests that inequities, among diabetic patients, in the use of eye care services by an ophthalmologist remain after differences based on age, sex and duration of diabetes were accounted for.

Decomposition analyses: Contribution of Need, Non-need and Residuals

Table 3.7 shows the contributions for each covariate and the percentage contribution of each to the overall income-related RCI in the use of eye care services. The largest contribution to income-related RCI for eye care services comes from MDI. Place of residence - urban and rural areas- was the second largest contribution to the income-related RCIs over time. Aboriginal status also contributed to "pro-rich" disparities in eye care services among diabetic patients. Over the 15-year period, the contribution of the AHS zones to total inequality has fluctuated and, in more recent years, the contribution became smaller and then became a negative contribution to "pro-rich" disparities (i.e., reduction of a pro-rich disparity).

For MDI-related RCIs, the largest contribution was consistently from material deprivation itself (Table 3.8). The contribution of MDI to total inequality was about 30% in 1995, but this increased to 67% by 2005 and remained the largest contribution to the MDI-related RCI. Place of residence - urban versusrural areas- wasthe second largest contribution according to the MDI-related RCI decomposition analyses. Unlike the negative contribution to income-related RCIs, the combination of need factors (i.e., age-sex interaction and duration of diabetes) showed a small positive value, indicating a relatively small contribution to a "pro-rich" direction, except for 2009 when the contribution was to a "pro-poor" direction. In relation to the AHS zones, the "pro-rich" contributions to the MDI-related RCI were found although the magnitude of the contributions became smaller in 2007 and for every year after it showed negative contributions to the MDI-related RCIs.

Table 3.9 demonstrates contributions for each covariate to SDI-related RCI in the use of eye care services over the 15-year period. In 2009, 68% of SDI-related RCI in the use of eye care services was explained by social deprivation itself. Place of residence –urban or rural areas- contributed from 27% to 36% of the "pro-poor" direction over the 15 year period. In addition, need factors such as age-sex interaction and duration of diabetes contributed to "pro-poor" RCIs over the same period. It is noteworthy that AHS zones contributed to "pro-poor" RCIs from 1995 to 2003, with a decreasing contribution to the total RCIs. After 2004, the contribution of AHS zones became a negative value, indicating that the contributions of AHS zones contributed to the "pro-rich" direction of SDI-related RCIs.

3.4. Discussion

Major contributors to existing socioeconomic inequities

While the contribution of each determinant varies, we observed two major factors that caused inequities across income- and MDI-related inequities – material deprivation and urban and rural place of residence. For both income and MDI-related inequities, material deprivation was unsurprisingly found to be the most important contributor to the "pro-rich" inequity – accounting for about 25 to 124%of absolute percentage of contribution to the measured RCIs over the follow-up period. This finding suggests that material deprivation is responsible for presenting important barriers to use of eye care services among diabetic patients under Canada's publicly funded health care system. This finding is consistent with previous research on eye screening services in patients with diabetes in the U.K and Australia. These studies indicate that living in deprived area is known to be associated with substantial variation in the uptake of screening service among diabetic patients (16, 18, 20).

The lesser contribution of income to pro-rich inequity in the use of eye care services may be explained by the fact that the aim of the Canadian healthcare system to provide healthcare services regardless of ability to pay works well in the case of provision of eye care services by an ophthalmologist among diabetic patients in Alberta. However, the contribution of income to overall pro-rich inequity cannot be overlooked. In fact, income was observed to be the largest contributor in both 2001 and 2002 when contributions of material deprivation were smaller than those of income. Several studies have revealed inequities in specialist care, suggesting a trend that favours higher-income individuals in specialist care services under the publicly funded health care system (9, 13, 22). Both higher educational attainment and higher income have been associated with higher rates of initial appointments for specialist care (9, 38). The contribution of place of residence to economic-related RCIs, appears to reflect, at least in part, the fact that urban residence is closely correlated with higher income; people living in urban areas tend to have both higher income and education in addition to secure employment status (17). In fact, according to our decomposition analysis of both income- and MDI-related RCIs, lower income and more materially deprived individuals are concentrated in rural areas. This may explain why place of residence has appeared as major contributor to economic-related RCIs. At the same time, the distribution of ophthalmology services is more concentrated in urban areas, facilitating easy access to the services for more affluent urban dwellers (39).

Social deprivation-related inequities were largely explained by social deprivation itself over time and this finding suggests that social deprivation needs to be main interest of health care policy in order to reduce social deprivation-related inequities in the use of eye care services among diabetic patients. The potential explanations for “pro-poor” inequities related to social-related RCIs are several. “Pro-poor” inequities may be explained by the fact that most urban areas in Alberta have lower SDI, which tells us that urban dwellers are more likely to live in areas that while more “socially deprived” have greater availability of ophthalmology services. In fact, the SDI-related RCIs, stratified by place of residence, indicate that the RCIs in urban areas were consistently “pro-poor” while those in rural area were “pro-rich”. Due to the complexity of the concept of social capital, it has been suggested that not all component of social capital may be related to use of health care services (40). To understand the association between social deprivation and the use of eye care services, further investigation is needed.

Aboriginal status also emerged as a major contribution to the “pro-rich” inequity in the use of eye care services. Access to health care is an issue for Aboriginal populations as they are less likely than the overall population to regularly visit a physician, and are more likely to report having unmet health care needs (41). For example, the vast majority of First Nations people with diabetes who live on reserves in British Columbia do not have access to annual examinations by an eye care professional (42). This fact might influence our interpretation of the results that Aboriginal populations encounter difficulties in receiving eye care services. Given the fact that a large proportion of the Aboriginal populations is concentrated in the AHS North zone, and live in rural areas, they might face more complex barriers to the use of eye care services.

Concern with inequities in eye care services related to place of residence and Aboriginal populations have been previously been identified in Alberta (43). To overcome geographic barriers to eye care services, the Department of Ophthalmology at the

University of Alberta developed a tele-ophthalmology program in 1998 (43). Alberta's comprehensive tele-ophthalmology program enables specialists to provide standard eye care services and diagnose ocular complications. The implementation of Alberta's tele-ophthalmology program may have influenced changes in direction and magnitude of inequities observed after 1998 in rural areas and among Aboriginal individuals. For example, income-related RCI were "pro-poor" in the Aboriginal population before 1998, but thereafter changed to "pro-rich" disparities. In addition, the magnitude of income-related RCI becomes slightly larger after 1998. Similar patterns were found in the direction of MDI-related RCI, which also reversed in the Aboriginal group after 1998. In addition, the magnitude of MDI-related RCI became smaller. This finding may suggest that the implementation of Alberta's tele-ophthalmology produced unintended inequities in rural areas and among Aboriginal populations in the province as a whole, while providing a better access to eye care services to individuals living in small and remote community in the AHS north zone.

In addition, residence in a specific AHS zone appeared to be a major factor contributing to "pro-rich" patterns of income- and MDI-related RCIs and to the "pro-poor" pattern of SDI-related RCI. In particular, we observed "pro-poor" contributions to SDI-related RCI until 2003, but, beginning in 2004, area of residence became a negative contributor - moving inequities to become "pro-rich" in 2004, and the magnitudes of the positive contributions became larger as one moved closer to 2009. It is possible that this trend might be associated with the regionalization implemented as a strategy for Alberta's healthcare system improvement. Prior to establishment of the current 5 AHS zones, health services in Alberta have undergone several governance re-organizations. Until March 2009, Alberta had 9 health regions (Chinook, Palliser, Calgary, David Thompson, East Central, Capital, Aspen, Peace Country, and Northern lights). Before 2003, there were 17 regional health authorities and 2 provincial boards for cancer and mental health (44). Reforms in the structure of health regions in the past were seen as opportunities to provide integrated health care service in addition to changes in governance and management systems (44). Thus, changes in the distribution of eye care services during our study period may reflect differences in these governance and management systems.

Finally, unlike economic-related RCIs, need factors consistently contributed to an increase in "pro-poor" direction of social-related RCIs. This may suggest that age, sex, and duration of diabetes must be considered if one wishes to reduce SDI-related inequities. In particular, individuals who are female and older than 65 years of age tend to contribute more to the pro-poor SDI-related RCIs. It is important to highlight that the contributions of need factors to the SDI-related RCIs increased over time and reached approximately 32% of contributions by 2009.

Limitations

While decomposition of the RCI allows one to identify the factors contributing most to observed inequities in health care, it should be recognized that the decomposition analysis is not able to provide causal pathways between socio-demographic determinants and health care use. The contribution of a determinant to the observed inequity usually depends on the products of its estimated elasticity with the health care outcomes at the sample means and the RCI of the factor itself, so it may fail to explain causal pathways (45). In addition, our socioeconomic indicator was at the level of Alberta's 70 sub-regions, so it may be unable to fully explain the variation of socioeconomic status with the same geographical region in the use of eye screening services, but at least it is possible to draw a conclusion that the variation between different sub-regions where there are different socioeconomic characteristics.

The decomposition method is a deterministic approach and there could be other factors (e.g., clinical, cultural and health care system related determinants not included in the model) that have may contributed to the inequities in eye care services. While we included age, sex, and duration of diabetes as 'need' factors for eye care services, there are many other important clinical indicators of need for eye care services. Unfortunately, our data were limited to the administrative databases, which lack information on these important clinical parameters. In addition, decomposing inequity based on need-adjusted utilization has been shown to suffer from several conceptual and measurement-related limitations (40). For example, our decomposition model assumes homogeneity in behaviours across socioeconomic groups of populations. Lastly, as provincial administrative data only included ophthalmology services, patients who used optometry services were unintentionally excluded in our analyses. As of the end of 2007, eye examinations by optometrists were covered by the provincial healthcare plan for patients with diabetes (3). Considering the large number of optometrists in Alberta (46), further examination of potential inequities, including information on services by both ophthalmologists and optometrists, is required.

3.5. Conclusion

Despite clear guidelines intended to address early detection and timely treatment of DR for all patients with diabetes, our findings suggest that individuals living with diabetes in

Alberta experience inequities in the use of eye care service based on socio-demographic characteristics unrelated to clinical need. In particular, material deprivation, urban/rural residence and AHS zone of residence appear to be the main contributors to the existing economic-related inequities in the use of eye care services. For social-related inequities, social deprivation, place of residence and AHS zones are the main contributors to existing SDI-related inequities, in addition to "need factors" of age, sex and duration of diabetes. In order to provide more equitable eye care services for all diabetic patients, the factors identified in this study should be further investigated, and if necessary, targeted by policy interventions at community, regional, and provincial levels.

Tables and Figures

Table 3.1. Income-related RCI by age, sex, place of residence, Aboriginal status, and duration of diabetes

Year	Age		Sex		Place of residence		Aboriginal status		Duration of diabetes	
	Young(<65)	Old(>= 65)	Male	Female	Urban	Rural	Aboriginal	Non-aboriginal	Shorter	Longer
1995	0.033	0.037	0.038	0.025	0.021	0.002	-0.040	0.030	0.032	0.035
1997	0.017	0.041	0.037	0.018	0.016	0.013	-0.033	0.026	0.034	0.016
1999	0.024	0.044	0.043	0.020	0.020	0.018	-0.023	0.029	0.038	0.021
2001	0.023	0.036	0.033	0.024	0.016	0.031	0.014	0.025	0.030	0.028
2003	0.016	0.041	0.032	0.021	0.012	0.022	0.023	0.024	0.029	0.023
2005	0.015	0.035	0.028	0.018	0.010	0.025	0.028	0.021	0.026	0.019
2007	0.031	0.035	0.037	0.024	0.018	0.033	0.038	0.027	0.033	0.029
2009	0.023	0.025	0.027	0.017	0.010	0.033	0.033	0.018	0.022	0.025

Table 3.2. MDI-related RCI by age, sex, place of residence, Aboriginal status and duration of diabetes

Year	Age		Sex		Place of residence		Aboriginal status		Duration of diabetes	
	Young(<65)	Old(>= 65)	Male	Female	Urban	Rural	Aboriginal	Non-aboriginal	Shorter	Longer
1995	0.087	0.086	0.088	0.090	0.055	0.056	0.053	0.082	0.091	0.083
1997	0.064	0.081	0.080	0.074	0.051	0.058	0.067	0.070	0.083	0.064
1999	0.062	0.077	0.077	0.067	0.048	0.051	0.038	0.065	0.082	0.054
2001	0.055	0.064	0.063	0.063	0.040	0.050	0.005	0.056	0.068	0.055
2003	0.046	0.066	0.061	0.057	0.038	0.024	-0.007	0.055	0.064	0.050
2005	0.040	0.060	0.056	0.050	0.037	0.022	-0.041	0.052	0.057	0.046
2007	0.048	0.052	0.055	0.052	0.040	0.010	-0.044	0.050	0.056	0.049
2009	0.034	0.045	0.044	0.042	0.031	0.007	-0.035	0.040	0.043	0.043

Table 3.3. SDI-related RCI by age, sex, place of residence, Aboriginal status, and duration of diabetes

Year	Age		Sex		Place of residence		Aboriginal status		Duration of diabetes	
	Young(<65)	Old(>= 65)	Male	Female	Urban	Rural	Aboriginal	Non-aboriginal	Shorter	Longer
1995	-0.050	-0.063	-0.053	-0.077	-0.034	0.034	-0.060	-0.062	-0.069	-0.048
1997	-0.037	-0.053	-0.040	-0.062	-0.028	0.029	-0.067	-0.047	-0.050	-0.049
1999	-0.026	-0.043	-0.029	-0.054	-0.023	0.050	0.007	-0.039	-0.041	-0.038
2001	-0.021	-0.039	-0.027	-0.043	-0.016	0.037	0.017	-0.033	-0.034	-0.032
2003	-0.021	-0.035	-0.027	-0.042	-0.018	0.025	0.015	-0.034	-0.035	-0.032
2005	-0.023	-0.035	-0.032	-0.040	-0.023	0.006	0.030	-0.037	-0.034	-0.036
2007	-0.019	-0.028	-0.022	-0.039	-0.020	0.017	0.029	-0.031	-0.032	-0.024
2009	-0.014	-0.027	-0.021	-0.034	-0.020	0.023	0.033	-0.028	-0.029	-0.020

Table 3.4. Income-related HIs in the use of eye care services among diabetic patients over a 15-year period

Income	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Need	-0.005	-0.005	-0.003	-0.004	-0.004	-0.004	-0.002	-0.003	-0.003	-0.003	-0.003	-0.004	-0.004	-0.004	-0.005
Non-need	0.026	0.030	0.023	0.029	0.027	0.023	0.025	0.022	0.021	0.020	0.017	0.019	0.024	0.024	0.019
Total inequality	0.031	0.036	0.027	0.033	0.031	0.027	0.028	0.027	0.026	0.026	0.023	0.024	0.030	0.027	0.021
Income HI	**0.036**	**0.041**	**0.030**	**0.037**	**0.035**	**0.031**	**0.031**	**0.030**	**0.029**	**0.029**	**0.026**	**0.029**	**0.034**	**0.031**	**0.026**

Table 3.5. MDI-related HIs in the use of eye care services among diabetic patients over a 15-year period

MDI	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Need	0.003	0.002	0.003	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Non-need	0.070	0.070	0.060	0.063	0.057	0.055	0.051	0.052	0.050	0.046	0.047	0.044	0.047	0.043	0.039
Total inequality	0.089	0.087	0.077	0.077	0.072	0.068	0.063	0.061	0.059	0.053	0.053	0.049	0.053	0.048	0.043
MDI HI	**0.086**	**0.085**	**0.073**	**0.075**	**0.070**	**0.066**	**0.060**	**0.059**	**0.057**	**0.051**	**0.051**	**0.047**	**0.051**	**0.047**	**0.041**

Table 3.6. SDI-related HIs in the use of eye care services among diabetic patients over a 15-year period

SDI	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Need	-0.010	-0.009	-0.007	-0.008	-0.008	-0.007	-0.006	-0.006	-0.007	-0.007	-0.008	-0.009	-0.009	-0.009	-0.009
Non-need	-0.046	-0.040	-0.035	-0.029	-0.023	-0.031	-0.021	-0.031	-0.029	-0.027	-0.032	-0.027	-0.025	-0.018	-0.020
Total ineqaulity	-0.066	-0.056	-0.051	-0.048	-0.041	-0.048	-0.035	-0.036	-0.035	-0.032	-0.036	-0.032	-0.031	-0.025	-0.028
SDI HI	**-0.056**	**-0.047**	**-0.044**	**-0.041**	**-0.034**	**-0.040**	**-0.029**	**-0.030**	**-0.028**	**-0.024**	**-0.028**	**-0.024**	**-0.022**	**-0.017**	**-0.019**

Table 3.7. Decomposition of income-related RCI, 1995-2009

Year	Decomposition	Need factors						Non-need factors										
		Age-sex2	Age-sex3	Age-sex4	SubAge-sex	Duration of DM	Need	Income	MDI	SDI	Residence	Aboriginal	Caglary	Central	Edmonton	North	Sub-AHS	Non-need
1995	% of contribution	-0.3	-3.1	-9.0	-12.4	-4.6	-17.0	-8.1	60.3	-3.9	21.1	5.0	-45.0	29.7	23.5	1.7	9.9	84.4
1996	% of contribution	-0.1	-2.1	-7.2	-9.4	-3.5	-12.9	-0.8	45.9	-1.4	17.4	4.3	-25.9	24.7	17.2	2.1	18.1	83.5
1997	% of contribution	0.2	-0.4	-5.6	-5.7	-5.7	-11.4	-4.3	49.6	-2.2	21.0	5.9	-43.8	31.9	23.9	1.0	12.9	82.9
1998	% of contribution	-0.1	-1.3	-7.2	-8.5	-4.2	-12.7	22.9	42.8	0.8	17.5	6.3	-51.5	29.5	20.7	0.7	-0.5	89.8
1999	% of contribution	0.0	-0.5	-8.0	-8.6	-4.5	-13.0	16.1	43.1	4.6	18.8	6.6	-57.5	30.3	23.4	0.6	-3.2	86.0
2000	% of contribution	0.0	-0.5	-10.1	-10.6	-4.1	-14.7	36.6	43.3	-12.0	21.2	8.2	-73.8	32.4	29.5	-0.7	-12.7	84.6
2001	% of contribution	0.3	1.2	-5.7	-4.3	-4.1	-8.4	41.9	26.0	-3.6	19.7	8.3	-61.8	32.3	25.6	-1.1	-5.0	87.2
2002	% of contribution	0.1	0.2	-7.9	-7.7	-3.0	-10.7	44.6	32.8	-26.7	20.6	4.0	-47.4	31.5	23.7	-1.9	6.1	81.3
2003	% of contribution	-0.1	0.5	-9.1	-8.7	-3.0	-11.7	23.6	31.4	-24.9	25.9	4.9	-34.1	31.9	24.5	-2.1	20.2	81.0
2004	% of contribution	-0.3	0.5	-8.9	-8.7	-3.0	-11.8	10.5	61.8	-30.4	21.7	2.2	-52.0	33.9	29.8	-2.1	9.6	75.5
2005	% of contribution	-0.3	-0.1	-11.1	-11.5	-3.8	-15.3	-46.2	124.4	-39.2	22.6	3.9	-55.9	35.0	30.5	-2.3	7.3	72.8
2006	% of contribution	-0.4	-0.5	-11.1	-12.1	-4.5	-16.6	-1.0	91.1	-40.4	21.1	4.7	-73.8	39.5	37.0	-2.0	0.6	76.0
2007	% of contribution	-0.3	-0.5	-9.4	-10.2	-4.4	-14.5	8.2	79.3	-33.5	19.5	5.8	-64.7	34.6	31.6	-1.8	-0.3	79.0
2008	% of contribution	-0.5	0.1	-10.3	-10.7	-5.3	-15.9	11.6	74.8	-27.1	23.6	7.6	-80.4	41.0	39.2	-1.8	-2.0	88.5
2009	% of contribution	-0.7	-0.2	-13.0	-14.0	-7.7	-21.7	9.0	86.4	-39.8	29.6	9.6	-101.8	52.5	48.8	-3.8	-4.2	90.5

*Age-sex2 Younger (<65)& Female
Age-sex3 Older(>=65)&Male
Age-sex4 Older(>=65)&Female

Table 3.8. Decomposition of MDI-related RCI, 1995-2009

Year	Decomposition	Need factors						Non-need factors										
		Age-sex2	Age-sex3	Age-sex4	SubAge-sex	Duration of DM	Need	Income	MDI	SDI	Residence	Aboriginal	Caglary	Central	Edmonton	North	Sub-AHS	Non-need
1995	% of contribution	0.5	1.1	1.4	3.1	-0.1	2.9	-2.3	29.2	0.8	22.3	4.8	-20.0	19.7	-10.6	35.1	24.2	79.0
1996	% of contribution	0.4	1.2	1.2	2.8	0.0	0.2	-0.3	26.5	0.4	20.2	4.9	-13.8	19.4	-9.6	32.9	29.0	80.7
1997	% of contribution	0.5	2.2	2.2	4.9	-0.6	4.4	-1.3	24.3	0.4	19.6	5.5	-19.9	21.4	-10.7	38.7	29.4	78.0
1998	% of contribution	0.3	1.6	0.8	2.6	-0.4	2.2	8.1	25.2	-0.1	19.2	6.9	-27.8	23.2	-11.2	38.3	22.5	81.7
1999	% of contribution	0.3	1.8	0.8	2.9	-0.6	2.3	5.8	25.7	-0.3	20.8	7.0	-31.4	24.5	-13.0	40.1	20.3	79.4
2000	% of contribution	-0.1	2.1	0.9	2.9	-0.5	2.3	12.6	23.9	0.4	21.8	8.0	-37.3	24.3	-14.1	41.5	14.4	81.1
2001	% of contribution	0.4	2.6	2.0	4.9	-0.7	4.2	16.2	16.1	0.1	21.8	8.7	-34.7	27.4	-15.4	42.0	19.3	82.1
2002	% of contribution	0.2	2.4	1.0	3.6	-0.3	3.3	17.2	20.3	-0.2	19.6	4.2	-26.4	26.6	-14.1	38.1	24.2	85.4
2003	% of contribution	-0.2	2.9	1.4	4.1	-0.3	3.8	9.0	19.1	-0.4	24.1	5.1	-18.6	26.2	-14.0	34.7	28.2	85.2
2004	% of contribution	-0.7	3.3	1.9	4.5	-0.2	4.3	4.4	38.0	-0.9	21.8	2.6	-30.8	29.7	-17.2	38.1	19.8	85.8
2005	% of contribution	-0.7	3.1	2.1	4.5	-0.3	4.2	-17.5	67.6	-1.5	20.0	4.1	-29.2	26.9	-14.9	33.3	16.1	88.7
2006	% of contribution	-1.0	3.2	2.2	4.4	-0.2	4.2	-0.4	56.8	-2.1	21.4	5.5	-44.1	34.8	-19.3	36.9	8.2	89.4
2007	% of contribution	-0.9	3.2	1.7	4.0	-0.6	3.5	3.7	56.2	-2.3	21.8	6.7	-43.6	34.2	-18.4	31.1	3.1	89.3
2008	% of contribution	-1.0	3.4	1.8	4.3	-0.8	3.5	5.2	52.1	-1.3	25.9	8.6	-53.1	39.5	-21.4	34.8	-0.2	90.2
2009	% of contribution	-1.2	3.8	2.2	4.7	-1.1	-0.6	3.6	53.4	-2.0	28.5	9.6	-59.7	44.2	-22.7	35.6	-2.5	90.5

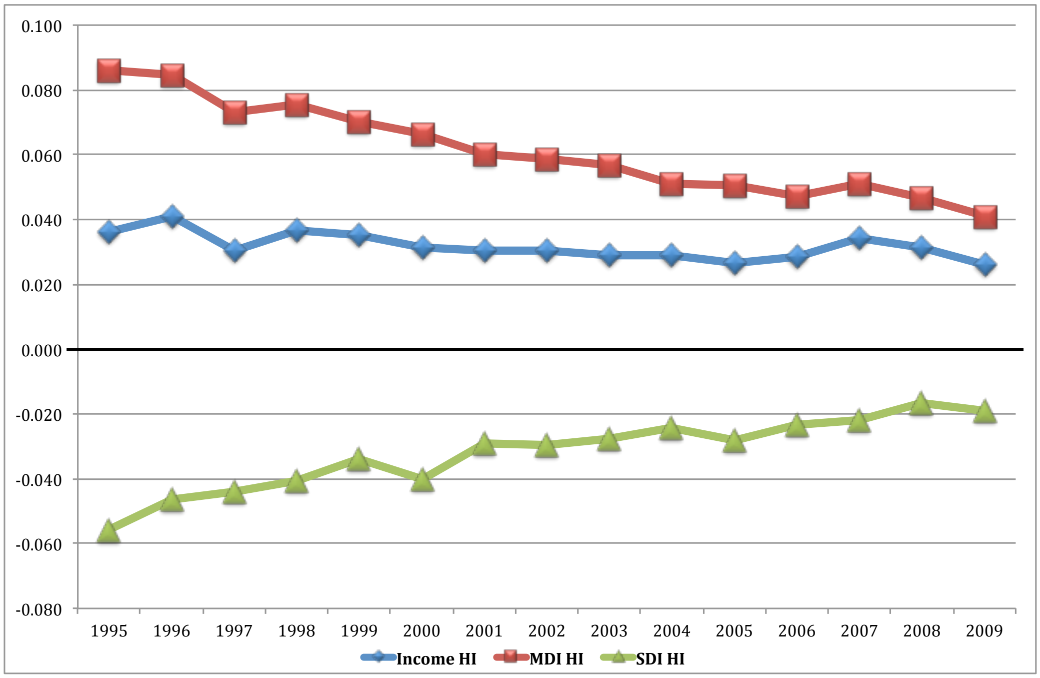
*Age-sex2 Younger (<65)& Female
Age-sex3 Older(>=65)&Male
Age-sex4 Older(>=65)&Female

Table 3.9. Decomposition of SDI-related RCI, 1995-2009

Year	Decomposition	Need factors						Non-need factors										
		Age-sex2	Age-sex3	Age-sex4	Sub Age-sex	Duration of DM	Need	Income	MDI	SDI	Residence	Aboriginal	Caglary	Central	Edmonton	North	Sub-AHS	Non-need
1995	% of contribution	1.1	3.3	8.4	12.8	2.3	15.1	0.8	9.5	7.2	32.9	3.1	-3.8	16.9	-31.7	35.9	17.3	70.8
1996	% of contribution	0.8	3.8	9.0	13.6	2.9	13.6	0.1	9.6	3.7	32.7	3.6	-2.8	18.4	-32.7	38.2	21.2	70.9
1997	% of contribution	0.6	2.9	7.0	10.5	3.1	13.6	0.4	8.1	4.5	29.2	3.6	-3.1	18.4	-36.0	43.0	22.3	68.2
1998	% of contribution	0.5	4.0	8.4	12.9	3.0	15.8	-3.2	8.9	-1.9	29.7	4.7	-3.6	19.6	-39.7	44.3	20.7	58.9
1999	% of contribution	0.5	4.1	10.3	14.9	3.5	18.4	-2.6	9.2	-9.6	34.4	5.0	-2.3	21.0	-50.0	49.9	18.6	55.0
2000	% of contribution	-0.1	3.8	10.0	13.7	1.8	15.5	-4.6	6.4	18.3	29.0	4.3	-0.3	15.6	-46.1	42.1	11.2	64.6
2001	% of contribution	0.3	3.1	9.5	13.0	3.2	16.2	-7.7	5.1	7.5	35.4	5.3	2.3	19.7	-59.9	52.7	14.8	60.5
2002	% of contribution	0.3	4.4	10.8	15.4	2.6	18.0	-8.1	5.6	46.9	27.0	2.4	3.5	15.6	-51.6	43.8	11.4	85.2
2003	% of contribution	-0.3	5.2	13.1	18.1	2.7	20.8	-4.4	4.9	43.0	32.2	2.8	4.0	13.4	-52.9	39.4	3.9	82.4
2004	% of contribution	-0.8	6.3	14.6	20.0	3.3	23.4	-2.2	5.0	55.7	28.0	1.4	8.9	12.6	-67.6	41.7	-4.4	83.6
2005	% of contribution	-0.8	5.4	14.0	18.6	3.5	22.1	7.5	6.4	54.4	21.9	1.8	8.8	8.5	-52.5	31.4	-3.9	88.1
2006	% of contribution	-1.2	6.1	16.8	21.8	5.2	27.0	0.3	4.6	66.4	24.1	2.4	16.5	9.5	-74.3	34.8	-13.5	84.3
2007	% of contribution	-1.2	6.4	17.4	22.7	5.7	28.4	-2.9	4.4	70.0	26.9	2.9	20.6	8.7	-81.0	32.4	-19.3	82.1
2008	% of contribution	-1.1	6.4	21.5	26.8	7.5	34.2	-4.5	3.3	65.5	34.3	3.8	32.5	7.4	-108.5	38.8	-29.8	72.6
2009	% of contribution	-1.1	5.5	20.3	24.6	7.5	32.1	-2.6	1.7	68.1	29.6	3.4	32.4	3.3	-95.0	31.7	-27.6	72.6

*Age-sex2 Younger (<65)& Female
Age-sex3 Older(>=65)&Male
Age-sex4 Older(>=65)&Female

Figure 3.1. The trends of horizontal inequity indices (HIs) over a 15-year period, 1995-2009



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Supplementary Tables

Table S3.1. Alberta physician claims data

Procedure	Code	Description
Retinal Laser Treatment (Retinal Photocoagulation)	28.5A	Focal and/or pan retinal photocoagulation
Vitrectomy Surgery	28.72A	Vitreous cavity washout
	28.72B	Total vitrectomy
	28.74A	Discission of vitreous/retinal adhesions
	28.74B	Stripping of premacular membrane, Associated vitrectomy and retinal encircling
Cataract Surgery	27.72	Insertion of intraocular lens prosthesis with cataract extraction, one-stage
Laser Treatment for Glaucoma	26.52 (1995-2004)	Laser peripheral iridotomy
	26.52A	Either laser peripheral iridotomy or argon laser trabeculoplasty or selective laser trabeculoplasty
End-Stage Glaucoma (Laser Treatment)	26.98B(2005-2009)	Diode laser cyclophotocoagulation (ciliary body ablation)
Glaucoma Surgery	26.2A (1995-2009)	Major glaucoma operation (trabeculectomy, EMS shunt)
	26.2B (1995-2009)	Ahmed shunt or Baerveldt shunt, with scleral patch graft
	26.25A (1998-2009)	Repeat trabeculectomy

Source: Alberta Diabetes Atlas 2011

Table S3.2. Distribution of eye care services by household income in 2009

Household income	Lowest (%)	2nd (%)	3rd (%)	4th (%)	Highest (%)	Total (%)
SEX						
Male	24.9	26.6	29.6	28.9	28.9	27.8
Female	27.3	31.0	31.6	30.1	30.5	30.1
Age						
Younger	21.9	22.3	24.5	24.8	24.0	23.5
Older	32.2	34.5	39.5	35.4	37.7	35.9
Place of residence						
Urban	27.8	33.2	28.3	30.5	30.0	30.0
Rural	21.2	26.2	18.7	30.0	25.2	24.3
Aboriginal status						
Yes	18.4	16.6	22.7	19.7	21.4	19.8
No	26.9	28.4	31.1	30.2	29.6	29.2
Duration of DM						
Shorter	23.1	23.7	26.9	26.2	25.9	25.1
Longer	34.2	38.6	39.8	37.2	40.3	38.0
Total	26.3	27.7	30.8	29.6	29.9	28.9

Table S3.3. Distribution of eye care services by material deprivation index in 2009

Material deprivation	Worst (%)	2nd (%)	3rd (%)	4th (%)	Least (%)	Total (%)
SEX						
Male	25.0	27.4	27.2	26.9	32.6	27.8
Female	28.2	28.5	30.0	29.7	34.3	30.1
Age						
Younger	22.9	22.2	22.9	23.0	26.9	23.6
Older	31.6	35.1	35.5	36.3	40.6	35.8
Place of residence						
Urban	26.8	29.8	30.1	30.1	33.3	30.0
Rural	24.0	25.3	21.3	24.3	25.5	24.1
Aboriginal status						
Yes	19.2	23.8	19.2	19.9	17.5	19.9
No	26.7	28.8	29.0	28.2	33.9	29.3
Duration of DM						
Shorter	22.7	24.8	24.8	24.7	28.9	25.2
Longer	35.0	36.1	37.5	38.2	43.5	38.1
Total	26.0	28.6	28.3	28.4	33.2	28.9

Table S3.4. Distribution of eye care services by social deprivation index in 2009

Social deprivation	Worst (%)	2nd (%)	3rd (%)	4th (%)	Least (%)	Total (%)
SEX						
Male	29.0	31.0	25.4	26.2	27.1	27.7
Female	32.1	34.8	26.9	27.7	29.3	30.1
Age						
Younger	24.3	23.8	23.7	22.6	23.1	23.5
Older	36.8	42.5	31.4	31.9	36.0	35.7
Place of residence						
Urban	30.9	30.1	32.5	27.3	29.0	30.0
Rural	26.2	21.3	19.9	25.3	28.3	24.2
Aboriginal status						
Yes	17.9	20.1	19.6	21.0	21.5	20.0
No	30.8	33.6	27.4	25.6	28.8	29.3
Duration of DM						
Shorter	26.8	28.7	23.2	22.9	24.2	25.1
Longer	39.1	43.1	35.2	34.8	38.0	38.1
Total	30.5	32.7	27.1	25.4	28.4	28.8

Chapter 4. Factors Associated with Eye Screening Services and Visual Impairment in Canadians Living with Type 2 Diabetes*

Abstract

Diabetic retinopathy (DR) is the major cause of visual impairment and blindness in diabetic patients. DR is known to be preventable and manageable, so regular eye screening for early detection and timely treatment is recommended. Underutilization of these services has been reported in Canada, although the impact of socioeconomic status (SES) on utilization and visual impairment is not well documented. We used data from the Survey on Living with Chronic disease in Canada (SLCDC)- Diabetes Component 2011, with respondents who self-reported having type 2 diabetes. Factors associated with the use of eye screening and visual impairment (i.e., DR, cataracts, glaucoma) were assessed using separate logistic regression models, weighted for the SLCDC sampling strategy, to represent that Canadian population. Respondents to the SLCDC-DM with type 2 diabetes (N=2,323) were 41.5% female, average age 63.4 (SD=0.4) years, with 44% having more than 10 years duration of diabetes. Amongst all patients with type 2 diabetes, factors associated with increased eye screening were discussion of diabetic complications with health professionals (OR=2.02; 95%CI: 1.28- 3.19), having private insurance (OR=3.23; 95%CI: 2.21- 4.73), and more than 10 years duration of diabetes (OR=1.53; 95%CI: 1.04 -2.25). Amongst patients with type 2 diabetes who reported having no visual impairment, patients with lower income were 40% (OR=0.60; 95%CI: 0.37-0.98) less likely to have eye screening compared to those with higher income. Amongst all patients with type 2 diabetes, visual impairment was more likely in female (OR=1.53; 95%CI: 1.12-2.09), older patients (OR=18.12; 95%CI: 6.63-49.51), those with poor self-rated

* The research and analysis are based on data from Statistics Canada and the opinions expressed do not represent the views of Statistics Canada.

health (OR= 3.10; 95%CI: 1.62-5.96), and with lower income (OR=0.60; 95%CI: 0.37 - 0.98). Our study found that patient's experience in discussing with health professionals and having private health insurance were main factors associated with the use of eye screening services, while age, sex, duration of diabetes, and self-rated health were related to visual impairment among type 2 diabetic patients. These factors need to be considered when the relevant health care services are provided to patients with type 2 diabetes.

4.1. Introduction

Diabetes retinopathy (DR) is the major cause of visual impairment and blindness, eventually affecting almost all patients with type 1 diabetes and approximately 60~80% of patients with type 2 diabetes (1-3). DR prevalence could be as high as 40% among Canadian patients with diabetes (4) and it is anticipated that the prevalence of DR will continuously increase as the number of diabetic patient escalates (5). DR is known to be preventable and manageable if diagnosed at an early stage (6-8). Regular eye screening for early detection and timely treatment decreases the risk of visual impairment and blindness caused by DR (9).

The estimated cost of DR screening is much lower than the estimated cost of social support and services related to visual impairment and blindness (2, 10). Thus, it is economically beneficial to provide regular DR screening to patients with diabetes (8); annual DR screening by an experienced health professional is strongly recommended for all patients with diabetes (11). Despite the clinical efficiency and economic benefits of regular screening, underutilization of DR screening services has been observed (2, 12, 13). In Alberta, only 58% of people with diabetes received an eye exam by an ophthalmologist within three years of diabetes onset (8). Similarly, in Ontario, only 19% of diabetic patients have undertaken follow-up eye screening after an initial eye examination (14).

Various barriers to receiving DR screening services have been identified, but lower socioeconomic status (SES) is thought to be one of the major factors associated with the failure to use eye screening services (15-19). Moss et al. found that higher education, higher income, and health insurance for eye examination were predictors of eye examinations for individuals in the US (20). Under the universal health care system in the U.K., the rate of DR screening was significantly lower in patients residing in deprived areas (16, 21, 22). Studies in Australia, Spain, and Hong Kong consistently found that those with lower income were at higher risk of underutilization (18).

As there is a strong socioeconomic gradient in ill health (23), and eye screening is less common in lower SES, it would follow that low SES is alsoa key predictor of increased rates of diabetic eye complications (12, 21, 24-29). In a review of the literature, Brown et al. found that lower SES, as measured by individual or household income, education, employment, occupation, or living in an underprivileged area, was associated with increased risk of microvascular disease, including diabetic eye complications (30). In a community-based study conducted in the U.K., lower education was found to be a predictor of diabetic eye complication, including DR (31).

There is little empirical evidence illustrating association between socioeconomic factors and visual impairment as well as relationship between these factors and use of eye screening services among Canadians living with diabetes. Therefore, the purpose of our study was to examine whether socioeconomic factors are associated with visual impairment and use of eye screening services in the Canadian diabetic population, using a nationally representative survey data.

4.2. Methods

Data Source

Our study used data from the Survey on Living with Chronic Disease in Canada – Diabetes Component 2011 (SLCDC-DM). The SLCDC is a cross-sectional survey sponsored by the Public Health Agency of Canada regarding the experiences of Canadians living with chronic health conditions (32). Individuals 20 years of age or older who self-reported diabetes on the 2010 Canadian Community Health Survey (CCHS) were invited to participate in the 2011 SLCDC-DM survey (32). Among the 3,590 CCHS respondents contacted, 2,933 ultimately participated in the SLCDC (32). The SLCDC-DM excluded full-time members of the Canadian Forces and residents of First Nations Reserves, Crown lands, institutions, and the three territories (32). We included only respondents who self-reported type 2 diabetes, based on the Ng, Dasgupta, and Johnson (NDJ) classification algorithm (33). Respondents with any missing values were excluded from our analysis.

Eye Screening Services

In the SLCDC survey, individuals were asked, "Have you ever had an eye exam where the pupils of your eyes were dilated?" and "When was the last time (you had your pupils dilated)?" Based on these two questions, we classified respondents into two groups: (1) patients who have had an eye exam within less than 2 years, as a regular eye screening group and (2) patients who have not had an eye exam or who had an eye exam 2 or more years ago, as a non-regular eye screening group. We ran two different models for eye screening services, first including all respondents with type 2 diabetes, and second including only those reporting no visual impairment, to assess factors associated with what could be considered preventive eye screening services.

Visual Impairment

SLCDC-DM participants were asked whether they have ever had eye complications diagnosed by health professionals, including DR, cataracts, or glaucoma. We classified patients who have been diagnosed with one of these eye complications as the "visual impairment group" and those who have never had a diagnosed eye complication as the "non-visual impairment group".

Predictive Factors

Independent predictor variables were selected based on Andersen's Health Behaviour Model (HBM) and determinants of eye health from previous research (34). According to Andersen's HBM, the determinants of health care services can be conceptualized into three categories: (1) predisposing characteristics, (2) enabling resources, and (3) need-based factors (34-36). Predisposing characteristics are generally demographic factors associated with the use of health care services such as sex, age, educational attainment, and other socio-demographic factors (34). Enabling resources refer to resources that are available to individuals for the use of health care services, such as insurance, availability of physicians, and income (34). Need factors are indicators of actual health status that are often associated with the use of health care services (36).

As predisposing factors we included age as categories (i.e., 20–49, 50–64, 65–79, 80 or older), sex, and marital status (i.e., married or living with partner and single or living alone), and educational attainment (i.e., less than secondary school, completed secondary school, other postsecondary school, and college or university level of postsecondary school). Respondents' demographic information was included as: a) non-immigrant/non-Aboriginal, b) immigrant, and c) Aboriginal. An individual's spoken language at home was also included.

As enabling resources we included self-reported household income (i.e.,< $15,000; $15,000–29,999; $30,000–59,999; $60,000–79,999; and $80,000 or more). Private insurance for eye care, and patients' experience in discussing diabetic complications with the family doctor were included in the model for eye screening services. We also included place of residence in urban or rural dwelling, and living in one of the following regions – Atlantic, Quebec, Ontario, Prairies, and British Columbia, as coverage and service delivery models are likely to differ by region.

For need-based factor, we included duration of diabetes, dichotomized at more or less than 10 years, and self-rated health classified as 4 categories: excellent/very good, good, fair, poor. Visual impairment was included as a need-based factor covariate in the analytic model for eye screening among all type 2 diabetic patients, but was excluded in the second model for eye screening where we excluded all type 2 diabetic patients with visual impairment. The re-categorization of all the variables was performed considering Statistics Canada's requirement of a minimum sample size in each dummy variable category.

All descriptive and logistic regression analyses were conducted using STATA 12 for Mac. Results are presented in terms of odds ratios (ORs) with 95% confidence intervals (CI) and p-values. Differences were considered statistically significant at $p<0.05$. The survey weights provided by Statistics Canada and bootstrap method were used for all analyses, to account for the complex survey design and sample selections, adjustments for non response, seasonal effects, and post-stratification (32). Weighted data are therefore representative of the survey populations and are required by Statistics Canada for reporting when producing population estimates (32).

4.3. Results

Of the 2,933 respondents to the SLCDC, 2,323 (79.2%) were classified as having type 2 diabetes and included in these analyses. Using the sample weights, this represented an estimated total population of 1,324,553 type 2 diabetic patients in Canada. The general characteristics of estimated population are summarized in Table 4.1. Among the total population, 72% reported receiving a dilated eye screening services within 2 years (Table 4.1). There were little differences in eye screening services across sex, age, marital status, education or ethnic/language groups. Across different income groups, the highest income group ($80,000 or more) reported the highest rate, 78% of eye screening services, but the differences were not statistically significant. Patients with longer duration of diabetes reported a higher rate of the eye screening services. Among four different self-rated health groups, the rate of eye screening services was higher in those reporting poor health. In addition, individuals living in Quebec showed the lowest rate of a dilated eye examination while those from Prairie provinces showed the highest rate of the examination (58% vs. 79%; $p<0.001$). Patients who had discussed diabetic complications with family physicians and who had private insurance for eye care showed higher rates of eye screening services compared to their counterparts. Approximately 84% of patients who had visual impairment had received eye screening services, while only 66% of patients without visual impairment reported having eye screening services in the past 2 years.

One-third (33%) of type 2 diabetic patients in our study reported having visual impairment including DR, cataract or glaucoma, as diagnosed by a health professional (Table 4.1). Female patients reported a significantly higher prevalence of visual impairment (40%) than men (28%). The prevalence of visual impairment increased substantially with age, and was higher in respondents who were single or living alone. Educational attainment and income were inversely related to the prevalence of visual impairment. There was no difference in the prevalence of visual impairment across the identified ethnic groups, but those respondents who spoke an official language at home had higher prevalence than those speaking non-official languages (34% vs 20%; $p=0.03$).

Visual impairment was more common in patients with longer duration of diabetes (44% vs24%; $p<0.001$), and in respondents who reported poor self-rated health (44%; $p<0.001$). There were no differences in the prevalence of visual impairment between urban and rural dwellers, or in the different regions of Canada. Discussion of diabetic complications with health professionals and private insurance for eye care appointment were not related to the prevalence of visual impairment.

Factors Related to Use of Eye Screening Services

In the first multivariable model including all type 2 diabetic patients, we found visual impairment, duration of diabetes, having private insurance for eye care, and discussion of diabetic complications with a health professional were the factors most strongly associated with use of eye screening services (Table 4.2). Patients with visual impairment were more than 2.5 (OR=2.60; 95%CI: 1.73- 3.91) times as likely, and patients living with diabetes for more than 10 years were more than 1.5 (OR=1.53; 95%CI: 1.04- 2.25) times as likely, to have received eye screening services within 2 years (Table 4.2). Patients who have private health insurance for eye care were much more likely to have eye screening services (OR= 3.23; 95%CI: 2.21-4.73). None of the socio-demographic, income or area of residence factors were significantly associated with the use of eye care services.

When we limited the analysis to type 2 diabetic patients without visual impairment, in order to see the association between SES and preventive eye screening services, we found similar results, in that duration of diabetes, discussing diabetic complications with health professionals and having private insurance were strongly and significantly associated with the use of eye screening services. However, there was a statistically significantly greater likelihood for respondents with higher incomes to have preventive eye screening services compared to those in the lowest income quintiles (Table 4.2). As a sensitivity analysis, were classified income quintiles into dichotomous variable as lower (less than $50,000) and higher (more than $50,000). In this analysis, those with lower income were 40% less likely (OR=0.60; 95%CI: 0.37-0.98) to have preventive eye screening services, after adjusting for other demographic and socio-economic factors [Table S4.1].

Factors Related to Visual Impairment

We found that sex, age, duration of diabetes, self-rated health, income, and region of Canada were significantly associated with visual impairment (Table 4.2). Female patients were more likely to have visual impairment compared to male patients (OR = 1.53; 95% CI: 1.12- 2.09). As might be expected, older patients were more likely to have visual impairment, particularly patients over the age of65 years. Compared to respondents living in Atlantic Canada, respondents in the other regions were more likely to report visual impairments, with the highest rates in British Columbia (OR= 2.12; 95%CI: 1.13- 3.97) and Ontario (OR= 1.72; 95%CI: 1.10- 2.69). Across income quintiles, individuals in the higher income groups were 45 to 55% less likely to have visual impairment compared the reference group, the lowest income quintiles (less than $15,000 per year) (Table 4.2).

4.4. Discussion

Regular eye screening is recommended for patients with type 2 diabetes in order to promote early detection and timely treatment of diabetic eye complications (11). For this reason, possible barriers for eye screening services and visual impairment should be identified and ameliorated. Our findings, using a nationally representative survey dataset, indicate that increased use of eye screening was associated with enabling factors such as private insurance for eye screening services and household income. Importantly, however, independent of these enabling socioeconomic factors, we found that discussing diabetic complications with health professionals was associated with a greater likelihood of receiving eye screening services. We also found that income was associated with the prevalence of visual impairment amongst patients with type 2 diabetes, and that the prevalence of visual impairment varied in regions across the country, with the lowest rates in Atlantic Canada.

It has been well documented that people with higher levels of education or income are more likely to use preventive or specialist care services compared to individuals with lower levels of education or income (31, 37, 38). Our findings agree with accumulated evidence related to the use of specialist care services that higher income is a predictor of the use of preventive eye screening services. One possible explanation is the relationship between income and a referral from a primary care physician, suggesting that individuals with higher income tend to be well aware of the need to use preventive services, so they are more likely to ask for a referral for these services (39, 40). Another explanation is that an individual's socioeconomic position has been shown to influence physicians' perception of patients' social class and intelligence (30). These perceptions may be related to a physician's preference to provide adequate counselling or referral services, which would result in the tendency of patients of lower income not to use the recommended eye screening services. There is consistent evidence identifyingincome as an important factor in receiving a referral to specialist services (41). These findings support the relationship between income and regular eye screening services in the diabetic population as well.

The association between private health insurance and eye screening services among patients with diabetes has been addressed in the literature. Several U.S. studies have previously identified private health insurance as one of the barriers to access eye screening services (20, 30, 42). Diabetic patients without insurance covering eye screening services are less likely to receive the recommended screening services that are commonly expectedin a private health care setting (42). However, even in Canada, our finding demonstrates that private insurance for eye care services is a predictor of regular eye screening services among patients with diabetes. This finding could be explained by the fact that eye screening services by an optometrist are sometimes not covered by provincial health care and require private insurance. Having private insurance for eye care appointments not covered by provincial insurance facilitates more frequent use of health care services. In Canada, as private health insurance is usually provided through the employer or more frequently found in higher paying positions, failing to cover eye screening through the publicly funded health care system could create inequity in health care for unemployed and precariously employed individuals (43).

Our study found that patients' experience in discussion of diabetic complications with health professionals is also an important indicator of receiving recommended eye screening services. This finding emphasizes the importance of the role of health professionals in diabetes management, in particular for eye screening services. One qualitative study found that detailed information about eye screening from primary care providers is an important factor in patient's receiving eye screening services (44, 45). A comprehensive primary care model has been suggested in order to enhance the responsibility of primary care providers and develop an effective collaboration between primary care providers and eye care services providers (46). Empirical evidence in the U.K. found that one such model, the Diabetes Managed Clinical Network, has made positive changes in collaborating closely with optometry and ophthalmology (45).

Clinical risk factors such as sex, age and duration of diabetes are associated with visual impairment. This finding is in line with accumulative epidemiological studies for visual malfunction in diabetic patients (47-52). Well-established clinical evidence indicates that the risk of eye disease such as DR, glaucoma, and cataract increases in both prevalence and severity in older age groups (47-49). Our study found a higher likelihood of visual impairment in females compared to males. This association remained significant after adjusting for various socioeconomic factors. Previous evidence on the association between sex and visual impairment among diabetic patients is controversial. The estimated prevalence of DR and vision-threatening DR was similar in male and female groups in a study estimating global prevalence of DR in diabetic population (50). Another study reported that males represent an independent risk factor for severe DR as well as early DR in patients with type 2 diabetes (51). In contrast, and consistent with our findings, data from the US National Society to Prevent Blindness (NSPB) indicated that the prevalence rate for diabetes-related visual impairment and legal blindness tended to be higher in females than in males (52).

Lower income is generally associated with visual impairment, suggesting that diabetic patients with lower income might have more visual impairment than diabetic patients with higher income (53). There is considerable evidence that socioeconomic status may determine the risk of diabetes-related complications such as retinopathy that ultimately have an impact on the quality of life (15, 21). There is evidence that diabetic patients of lower socioeconomic status, as measured by individual or household income, have increased risk of eye complications (30). Our findings support previous researchthat income is a predictor of visual impairment among diabetic patients (30). The causality between income and eye complication is still unclear but it can be argued that patients with visual impairment may impede participation in the labour force market, resulting in lower income. On the other hand, previous studies have suggested that health is generally influenced by income and is shaped over time by the socioeconomic status imposed on individuals at different stages of life (23, 54).

The higher prevalence of visual impairment in Ontario and British Columbia compared to Atlantic Canada is difficult to explain. While we controlled for age, sex, income and duration of diabetes, other factors not adequately controlled in our model might account for some of the difference, also called residual confounding. It did not appear that use of eye screening services differed across the same regions. Further study is required to understand the observed higher prevalence of visual impairment amongst diabetic individuals living in Ontario and British Columbia compared to other Canadian provinces.

Limitation

Our study has a number of limitations. First, due to the snapshot nature of the cross-sectional design, causal inferences cannot be inferred between various factors, including SES, and eye screening services, or visual impairment. The nature of the data collection also precludes the exclusion of reverse causality in our study findings. Second, the SLCDC- DM 2011 is a self-reported survey data and therefore prone to measurement error and biases, such as recall and social desirability bias. The latter is quite likely, given that the self-reported rates of regular eye screening services are higher than previous Canadian studies (8, 14). Another potential limitation is that sampling bias may limit the generalizability of findings; for example, residents of three territories and of First Nations reserves were not included in the SLCDC- DM 2011. Finally, the self-reported nature of the data does not provide clinical parameters, such as glycemic control, blood pressure, which would reflect the level of risk for diabetic eye disease.

4.5. Conclusion

Findings from our study highlight the importance of socioeconomic factors in determining the use of eye screening services and the risk of visual impairment, regardless of other factors that may confound or mediate these associations. Diabetic retinopathy is a treatable and preventable diabetic complication. Regular screening for diabetic eye disease and timely treatment are clinically effective and economically beneficial. In order to provide an eye screening and appropriate treatment to type 2 diabetic patients, the factors associated with use of eye screening services and visual impairment we identified need to consider when ophthalmology or optometry services are provided to type 2 diabetic patients.

Tables

Table 4.1. Characteristics of type 2 diabetic patients by eye screening services

Characteristics	Category	Total estimate population		Eye screening	P-vaule[b]	Visual Impairment[a]	P-value[b]
		N	%	%- Yes		%-Yes	
Total Population		1324553	100.0	72.0		32.7	
Sex	Male	774810	58.5	70.7	0.38	27.80	<0.001
	Female	549742	41.5	73.7		39.70	
Age	20-49	188680	14.2	70.2	0.51	10.70	<0.001
	50-64	538478	40.7	69.9		21.20	
	65-79	493328	37.2	75.2		45.90	
	80+	104067	7.9	70.5		69.90	
Marital status	Married/partnered	927550	70.0	72.5	0.55	27.60	<0.001
	Single/living alone	397003	30.0	70.6		44.60	
Education	Less than Secondary	198249	15.0	71.8	0.72	47.10	<0.001
	Secondary	166632	12.6	68.1		27.80	
	Other post-secondary	86964	6.6	75.8		31.50	
	Post-secondary	872708	65.9	72.3		30.50	
Demographic	Non-immigrant/non-Aboriginal	938678	70.9	71.3	0.80	34.20	0.29
	Immigrant	338760	25.6	73.6		28.40	
	Aboriginal	47115	3.6	27.0		34.80	
Official language at home	Yes	1212230	91.5	72.1	0.87	33.90	0.03
	No	112323	8.5	70.9		19.60	
Visual impairment	Yes	433246	32.7	83.7	<0.001	N/A	
	No	891307	67.3	66.3			

Duration of DM	Less than 10yrs	735895	55.6	66.8	<0.001	23.50	<0.001
	More than 10yrs	588658	44.4	78.4		44.20	
Self-rated Health	Excellent & very good	326026	24.6	73.2	0.09	23.40	<0.001
	Good	555678	42.0	69.3		30.60	
	Fair	286932	21.7	69.9		41.00	
	Poor	155917	11.8	82.6		44.30	
Income	Less than $15,000	96125	7.3	71.0	0.34	54.00	<0.001
	$15,000~29,999	249631	18.8	70.9		45.10	
	$30,000~49,999	334876	25.3	69.8		31.60	
	$50,000~79,999	341034	25.7	69.8		27.10	
	$80,000 or more	302887	22.9	78.0		23.30	
Residence	Urban	1018659	76.9	73.1	0.22	33.70	0.21
	Rural	305894	23.1	68.3		29.40	
Region	Atlantic	117450	8.9	72.2	<0.001	27.90	0.56
	Quebec	272315	20.6	57.5		31.50	
	Ontario	601503	45.4	75.6		33.40	
	Prairie	196330	14.8	78.9		31.50	
	BC	136955	10.3	74.5		38.00	
Discussion with Health professionals	Yes	1075094	81.2	75.8	<0.001	32.70	0.99
	No	249459	18.8	55.5		32.70	
Private Insurance	Yes	894791	67.6	80.7	<0.001	34.00	0.23
	No	429762	32.4	53.8		30.00	

[a] visual impairment included self-reported diabetic retinopathy, cataracts or glaucoma

[b] univariate comparison with chi-square test

Table 4.2. Multivariate logistic regression for eye screening services, preventive eye screening services and visual impairment

Variable		Eye screening services			Preventive eye screening			Visual Impairment		
		OR	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
Predisposing Characteristic	*Sex*									
	Female	1.22	0.83 -1.78	0.31	1.28	0.80 - 2.05	0.31	1.53	1.12 - 2.09	0.01*
	Age									
	50-64	0.88	0.43 - 1.79	0.22	0.85	0.38 - 1.90	0.68	1.79	0.71 - 4.47	0.22
	65-79	0.98	0.49 - 1.96	0.14	1.15	0.51 - 2.63	0.73	6.31	2.47 - 16.11	0.00*
	80-	0.86	0.38 - 1.95	0.21	1.08	0.37 - 3.20	0.88	18.12	6.63 - 49.51	0.00*
	Marital status									
	Single	0.84	0.57 - 1.24	0.38	0.82	0.51 - 1.33	0.42	1.42	0.99 - 2.03	0.05
	Education									
	Secondary	0.82	0.46 - 1.46	0.51	0.61	0.29 - 1.26	0.18	0.61	0.36 - 1.02	0.06
	Other post-sec	1.16	0.55 -2.47	0.70	0.94	0.41 - 2.16	0.89	0.92	0.48 - 1.76	0.80
	Post-sec	1.01	0.63 - 1.62	0.97	0.77	0.43 - 1.36	0.36	1.26	0.86 - 1.85	0.24
	Demographic									
	Immigrant	1.00	0.56 - 1.78	1.00	1.10	0.53 - 2.26	0.80	0.89	0.54 - 1.46	0.64
	Aboriginal	0.73	0.34 - 1.58	0.42	0.78	0.27 - 2.23	0.64	0.99	0.45 - 2.19	0.98
	Official Language									
	No	1.14	0.47 - 2.77	0.78	1.00	0.33 - 3.03	0.99	0.45	0.16 - 1.28	0.13
Need factors	*Visual impairment*	2.60	1.73 - 3.91	0.00*						
	Yes									
	Duration of DM									
	> 10yrs	1.53	1.04 - 2.25	0.03*	1.53	0.93 - 2.50	0.09	2.14	1.58 - 2.89	0.00*
	Self-rated health									
	Good	0.75	0.48 - 1.16	0.20	0.74	0.44 - 1.26	0.27	1.47	0.98 - 2.21	0.06
	Fair	0.69	0.41 - 1.16	0.16	0.65	0.35 - 1.23	0.18	2.03	1.27 - 3.24	0.00*
	Poor	1.40	0.64 - 3.08	0.40	1.76	0.60 - 5.13	0.30	3.10	1.62 - 5.96	0.00*

	Income									
	-29,999	1.27	0.64 - 2.51	0.50	2.22	1.02 - 4.85	0.04*	0.66	0.40 - 1.11	0.12
	-49,999	1.12	0.55 - 2.27	0.76	1.47	0.68 - 3.18	0.33	0.50	0.28 - 0.87	0.01*
	-79,999	1.13	0.51 - 2.47	0.77	1.51	0.64 - 3.56	0.34	0.45	0.24 - 0.83	0.01*
	80,000 more	1.51	0.66 - 3.44	0.33	2.19	0.87 - 5.52	0.10	0.56	0.27 - 1.16	0.12
	Urban/rural									
	Urban	1.07	0.72 - 1.59	0.73	1.07	0.67 - 1.72	0.77	1.05	0.70 - 1.57	0.81
Enabling factors	*Region*									
	Quebec	0.86	0.47 - 1.55	0.61	0.76	0.37 - 1.55	0.45	1.42	0.88 - 2.30	0.15
	Ontario	1.03	0.64 - 1.66	0.91	1.09	0.63 - 1.89	0.75	1.72	1.10 - 2.69	0.02*
	Prairie	1.32	0.81 - 2.16	0.26	1.50	0.82 - 2.72	0.18	1.36	0.82 - 2.27	0.24
	BC	1.07	0.58 - 1.97	0.83	1.26	0.60 - 2.64	0.55	2.12	1.13 - 3.97	0.02*
	Discussion with HP									
	Yes	2.02	1.28 - 3.19	0.00*	2.54	1.42 - 4.53	0.00*	1.39	0.96 - 2.02	0.08
	Private Insurance									
	Yes	3.23	2.21 - 4.73	0.00*	3.71	2.33 - 5.91	0.00*	1.12	0.81 - 1.56	0.48

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Supplementary Table

Table S4.1. Multivariate logistic regression for preventive eye screening services in type 2 diabetic patients

Variable		OR	95% CI	P-value
Predisposing Characteristic	*Sex*			
	Female	1.28	0.80 - 2.06	0.30
	Age			
	50-64	0.75	0.34 - 1.68	0.49
	65-79	1.14	0.50 - 2.59	0.75
	80-	1.15	0.40 -3.25	0.80
	Marital status			
	Single	0.84	0.53 - 1.26	0.34
	Education			
	Secondary	0.56	0.27 - 1.16	0.12
	Other post-sec	0.82	0.35 - 1.92	0.65
	Post-sec	0.65	0.36 - 1.15	0.14
	Demographic			
	Immigrant	1.22	0.61 - 2.45	0.57
	Aboriginal	0.8	0.28 - 2.30	0.68
	Official Language at home			
	No	0.98	0.33 - 2.89	0.99
Need factors	*Duration of DM*			
	more than 10yrs	1.52	0.93 - 2.48	0.36
	Self-rated health			
	Good	0.79	0.47 - 1.31	0.36
	Fair	0.68	0.37 - 1.26	0.23
	Poor	2.03	0.66 - 6.26	0.22
Enabling factors	*Income*			
	Less than 50,000	0.6	0.37 - 0.98	0.04*
	Urban/rural			
	Urban	1.12	0.70 - 1.80	0.62
	Region			
	Quebec	0.75	0.37 - 1.53	0.43
	Ontario	1.03	0.60 - 1.75	0.92
	Prairie	1.44	0.80 - 2.60	0.22
	BC	1.21	0.58 - 2.51	0.62
	Discussion with HP			
	Yes	2.4	1.36 - 4.24	0.00*
	Private Insurance			
	Yes	3.46	2.20 - 5.45	0.00*

Chapter 5. Income-related Disparities in Visual Impairment and Eye Screening Services in Type 2 Diabetic Patients in Canada*

Abstract

Diabetic retinopathy (DR) is the major cause of visual impairment and blindness among working age individuals with diabetes. For early detection and timely treatment, regular eye screening for DR is strongly recommended for all diabetic patients. Despite the availability of eye screening services under Canada's universal health care system, underuse of routine eye screening services is observed. Among various factors, it is acknowledged that income plays a crucial role in health and health care. The purpose of this study was to measure income-related disparities in visual impairment and use of eye screening services amongst Canadian living with type 2 diabetes. In addition, the study aimed to identify contribution of various socio-demographic determinants to income-related disparities. Our study used data from the Survey on Living with Chronic Disease in Canada- Diabetes Component 2011 (SLCDC-DM). A total of 2,323 patients with type 2 diabetes were included in our study. To examine income-related disparities in visual impairment and use of eye screening services, we used the relative concentration index (RCI), horizontal inequity index (HI) and decomposition of the RCI. Our results suggest that individuals with lower income tend to have more visual impairment compared to those with higher income. The main contribution to the observed income disparity in visual impairment came from age and marital status, suggesting the observed disparities in visual impairment could be interpreted as an inequality because age and marital status are more likely to be considered as unmodifiable factors. With respect to eye screening services, patients with higher income were more likely to use more eye screening and

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* The research and analysis are based on data from Statistics Canada and the opinions expressed do not represent the views of Statistics Canada.

preventive eye screening services. The main contributors of the observed disparities were income, having private health insurance and patient's experience in discussing diabetic complications with health professionals. After health care need standardization, HIs still indicate "pro-rich", suggesting the observed disparities in eye screening services could be the result of inequities. Our findings suggest that the identified determinants could be considered when health and health care policies are developed in order to tackle disparities in visual impairment and the use of eye screening services in diabetic population.

5.1. Introduction

Diabetic retinopathy (DR) is the leading cause of visual impairment and blindness among working age individuals with diabetes (1-3). DR is also associated with worse health outcomes, which may ultimately impede the patient's participation in economic activity and decrease his or her quality of life (4, 5). Vision impairment caused by DR can be preventable and is more manageable when the disease is diagnosed and treated at an early stage; however, once vision loss develops, it cannot be recovered (6-8). Therefore, regular eye screening by a health professional is strongly suggested for all diabetic patients for early detection and timely treatment (2, 7).

DR is the primary cause of blindness in North America (9). It is responsible for about 12% of all new cases of blindness, affecting more than 8,000 individuals each year in the U.S (10). In Canada, DR causes an estimated 600 new cases of blindness each year (11). Considering the increasing number of diabetic patients in the Canadian population, the prevalence of DR and blindness is expect to continuously increase (12). One Canadian study has estimated that DR prevalence could be as high as 40% among diabetic patients (10). It has also been estimated that nearly half a million Canadians currently have some form of DR and approximately 100,000 Canadians have a more advanced form of the disease defined as proliferative DR, diabetic macular edema or both (9). Glaucoma and cataracts also occur earlier and more frequently, and progress more rapidly, in patients with diabetes (13).

Cumulative evidence suggests that regular screening for DR is clinically effective and economically beneficial (2, 14). This service is available under Canada's universal health care system, which aims to eliminate financial barriers to health care services. Despite the availability of eye screening services within the publicly funded health care system, underuse of routine eye screening services is reported (15, 16). In a study that estimated the use of eye care services in five provinces and one territory, only 68% of diabetic patients had received the recommended level of eye screening service (17). In Alberta, only 55% of patients received an eye examination by an ophthalmologist within three years of being diagnosed with diabetes, and the yearly number of eye examinations by ophthalmologists has decreased over the last 15 years (2). In Ontario, only 19% of diabetic patients have undertaken follow-up eye screening after their initial eye examinations (18).

Among various factors, income has been identified as a key factor associated with both visual impairment and use of eye screening services (19-22). In a literature review, Brown et al. found that low socioeconomic status (SES), as measured by income, is associated with increased risk of microvascular disease including ocular complications (19). Moss et al. found diabetic patients in higher income groups were more likely to receive eye screening services compared to those in lower income groups (20). Despite a bourgeoning literature revealing income-related inequities in health and health care, however, there is little evidence available regarding visual impairment and use of eye screening services among type 2 diabetic patients.

The purpose of this study was to measure income-related disparities in visual impairment and use of eye screening services amongst Canadians living with type 2 diabetes. Also we aimed to identify the contribution of various socio-demographic determinants to income-related disparities in visual impairment and use of eye screening services.

5.2. Methods

Data source

Our study used data from the Survey on Living with Chronic Disease in Canada—Diabetes Component 2011 (SLCDC-DM). The SLCDC is a cross-sectional survey on the experiences of Canadians living with chronic health conditions (23). Individuals 20 years or older who self-reported diabetes diagnosed by a health professional in the 2010 Canadian Community Health Survey (CCHS) were invited to participate in the 2011 SLCDC-DM (23). The SLCDC-DM excludes individuals who are full-time members of the Canadian Forces and residents of First Nations reserves, Crown islands, institutions, and the three territories (23). 2,933 individuals (out of a total of 3,590 CCHS respondents who were eligible) responded and participated in the 2011 SLCDC-DM survey. We only included respondents who self-reported type 2 diabetes, based on the Ng, Dasgupta and Johnson (NDJ) classification algorithm (24). Respondents with any missing value were excluded from our analysis.

Outcome variables – visual impairment and eye screening services

In order to assess visual impairment, SLCDC-DM survey participants were asked the following question: *"Have you ever had any of the following conditions diagnosed by a health professional: diabetic eye disease or diabetic retinopathy; partial or complete blindness; cataracts; glaucoma?"*. Patients who reported one of these eye complications were classified as individuals with visual impairment and patients who did not report any eye complication were classified as individuals with no visual impairment.

Participants were also asked to self-report (i) use of dilated eye screening services and (ii) the last time a dilated eye screening service was used. Patients who had undergone dilated eye screening within two years were classified as regular eye screening receivers whereas patients who had not undergone dilated eye screening or had undergone dilated eye screening two or more years before our study were defined as non-regular eye screening receivers. We developed two different models for eye screening services, first including all respondents with type 2 diabetes, and second including only those reporting no visual impairment.

Socioeconomic factors

We used total household income as the measure of socio-economic status. Respondents were asked to estimate their total household income in the past 12 months. This self-reported income was categorised into 10 income decile groups based on the adjusted ratio of individual's total household income to the low income cut-off corresponding to household and community size (25). For our decomposition models, socio-demographic covariates for use of eye screening services and visual impairment were selected based on Andersen's Health Behaviour Model (HBM) and determinants of health care utilization and health outcomes from previous studies (26). These variables included age group (i.e., 20-49, 50-64, 65-79, 80 or older), sex, marital status (i.e., married or living with partner and single or living alone), demographic status (i.e., non-immigrants, Aboriginals and immigrants), and duration of diabetes. In addition, educational attainment (i.e., less than secondary school, completed secondary school, other postsecondary school, and college or university level of postsecondary school), place of residence (i.e., urban or rural) and region of Canada, self-rated health (i.e., excellent/very good, good, fair, bad), whether private insurance for eye care appointments was available, and experience discussing diabetic complications with a health professional were included variables.

The Relative Concentration Index (RCI) and decomposition analysis

To examine income-related disparities in visual impairment and use of eye screening services, we used the Relative Concentration Index (RCI). The RCI was proposed by Kakwani and Wagstaff (27, 28) and is widely used as a standard measure of inequality in health and in health care (29, 30). To measure the RCI we created a 2-dimensional graph called a Concentration Curve (CC) by plotting cumulative percentages of the respective outcome variables—eye screening service use or visual impairment—on the y-axis and cumulative distributions of individuals by household income on the x-axis. The CC allowed us to measure the distribution of the use of eye screening services or visual impairment by aggregating across individuals for income rankings. The line of equity (i.e., a 45-degree line) on the CC represents an equal distribution of the outcome variables (i.e., 20%) across different income rankings. Based on the separate CC, we obtained the RCIs of each of the outcomes—visual impairment and eye screening services. The RCI is defined as twice the area between the CC and the line of equity and typically ranges between -1 and 1. The RCIs for visual impairment and the use of eye care services were calculated with the equation (1) (30, 31) :

$$RCI = \frac{2}{N\mu}\sum_{t=1}^{n} h_i r_i - 1 - \frac{1}{N}, \tag{1}$$

Where h_I is the outcome, μ is the mean of the outcome, and r_i = *i*/N is the fractional rank of individuals *I* in the median household income distribution, with *i* = 1 being the lowest and *i* = N being the highest. If there is no income-related disparity (i.e., the CC is equal to the line of equity), the RCI is zero. The convention is that the RCI takes a negative value when the CC lies above the line of equity, indicating a disproportionate concentration of health or health care among the lowest quintiles (i.e., "pro-poor"), and a positive value when the CC lies below the line of equity (i.e., "pro-rich"). The greater the value of the RCI, the greater the degree of concentration in a negative or positive direction.

After obtaining the RCIs for visual impairment and the use of eye screening services, we applied the decomposition method proposed by Wagstaff et al. (32) to assess the major contributors to income-related RCIs. The basic idea of decomposition is measuring whether socio-demographic factors related to income such as age, sex, marital status, educational attainment and complementary insurance coverage, etc. (i.e., explanatory variables), are contributing to the overall level of income-related inequity (32, 33). Assuming that the outcome variable is linked to k determinants through a linear regression, it is possible to decompose the RCI by those k determinants. Decomposition of the RCI is represented by equation (2):

$$RCI = \sum_K (\beta_K x_{K/}\, \mu) C_K + \frac{GC_\varepsilon}{\mu} = \ C_{\hat{y}} \ + GC_\varepsilon/\mu, \qquad (2)$$

Where μ is the mean of the proportion of visual impairment or the use of eye screening services, β_k is the regression coefficients for the explanatory variables, x_k is the mean of individual explanatory variables, C_k is income-related RCI, and GC_ε is the generalized concentration index for the error term. The overall disparity in visual impairment or eye screening services has two components: (i) an explained component and (ii) unexplained component. The explained component denotes the impact of socio-demographic determinants on visual impairment or eye screening services and the extent of unequal distribution of each determinant across different income groups. The residual component reflects income-related disparities that are not explained by systematic variation of the determinants in the model.

In addition to decomposing the RCIs, we calculated the horizontal inequity index (HI) for the eye screening service models. HI represents the principle of equal treatment of people in equal need, regardless of socio-demographic factors; it provides important evidence to distinguish between inequity and inequality (34). Inequity is the result of systematic and potentially remediable variation between population groups defined socially, economically, or geographically and this is distinguished from inequality, which simply indicates biological difference or individual’s choice (35). HI can be obtained by subtracting the RCI of need-standardization from the total RCI as proposed by Wagstaff et al. (32). A positive (negative) value of HI indicates horizontal inequity favoring the better-off (worse-off); a zero value of HI means no horizontal inequity (i.e., eye screening and need are proportionally distributed by need across income distribution). In decomposition analysis for eye screening services, need factors for eye screening services were represented through age, sex, and relevant health variables such as duration of diabetes, and self-rated health, which reflect individual's healthcare needs (36, 37). RCIs, HIs, and the decomposition of RCIs were estimated using STATA 12 for MAC and sampling weights provided by Statistics Canada and bootstrap method were applied in the analyses.

5.3. Results

Descriptive statistics

We analyzed the data for 2,323 type 2 diabetic patients after removing missing data for income and socio-demographic variables. Descriptive statistics for the sample, and the population they represent, are presented in the previous chapter. Table 5.1 shows the weighted percentage of visual impairment, eye screening and preventive eye screening services according to self-reported household income quintiles. Patients with type 2 diabetes from lower income quintiles groups, in general, had a higher percentage of visual impairment. The patterns of relationship between income and preventive eye screening services, however, were different: only those in higher income groups used more eye screening services.

Relative Concentration Index (RCI) and Horizontal inequity index (HI)

For visual impairment, a small, but pro-poor disparity was observed among type 2 diabetic patients (RCI = -0.104) (Table 5.2). This result indicates that more visual impairment was concentrated in diabetic patients with lower income. There appeared to be consistent, although small, pro-rich disparities in eye screening services and preventive eye screening services among type 2 diabetic patients (Table 5.2), suggesting that type 2 diabetic patients with higher incomes were more likely to receive eye screening services. The magnitude of the RCI for preventive eye screening services, which only included type 2 diabetic patients without visual impairment, was slightly larger than the one for eye screening services in all type 2 diabetic patients (0.042 versus 0.025). However, the 95% confidence intervals overlap (Table 5.2).

Decomposition of the RCI

The decomposition analysis for eye screening services and preventive eye screening services indicate that horizontal inequity exists. The observed RCI in both eye screening services and preventive eye screening by income does not necessarily suggest "unfairness" because of the underlying unequal distribution of need factors in the population (34). After adjusting need factors that predict health care use including sex, age, duration of diabetes, and self-rated health, HI still remains positive, indicating "pro-rich inequity in the use of eye screening services and preventive eye screening services (Table 5.2).

Table 5.3-5.5 report the total RCI decomposition for the models referring to visual impairment, eye screening services and preventive eye screening services, respectively. The first column in each table shows elasticity for each determinant. The elasticity shows a percentage of visual impairment or eye screening services due to a percentage change in each determinant. Decomposition of concentration indices also showed the expected distribution of determinants in income groups. Positive concentration index indicates concentration of individuals with specific characteristics in higher income group.

Finally, the last three columns report, respectively, absolute, percentage and aggregated contributions to total income-related disparities. Positive contribution of each socio-demographic factor indicates that the factor is associated with both income and visual impairment or eye screening services. In other words, positive contribution of the determinant implies that the observed disparities can be *x* % reduced if the determinant were to be distributed equally across income quintile groups, or if the determinants was not associated with visual impairment or eye screening services. On the other hand, negative contribution of a factor indicates contributing to a reduction in income-related disparities.

The decomposition results show that age contributes 42% to the observed inequality while income only contributes about 18% to the inequality in visual impairment among type 2 diabetic patients (Table 5.3). The second greatest contributor was marital status. These results demonstrate that the observed disparity in visual impairment would be 42% and 25% lower respectively if patients who are older or live alone were equally distributed across the income range or if being old and single had no effect on visual impairment. Sex and duration of diabetes contributed respectively 9.5% and 5.3 % to the observed inequality in visual impairment in type 2 diabetic patients (Table 5.3). According to the decomposition results for eye screening services in type 2 diabetic patients, the greatest contributions to inequity in the use of eye screening services came from income, which explains 88 % of inequity in the use of eye screening services (Table 5.4). Having private insurance, discussion of complications with health professionals, marital status and region of residence also contribute to the pro-rich disparities in the use of eye screening services. The negative contribution from visual impairment indicates contribute to a reduction in the observed pro-rich disparities.

The decomposition results for preventive eye screening services (Table 5.5) indicates that the observed disparities can be explained by income (73.7 %), private insurance (42.8%) and patients experience in discussion of diabetic eye complications with health professionals (20.6%). In addition to these three main contributors, marital status and regions of residence contributed to pro-rich disparities in the use of preventive eye screening services.

5.4. Discussion

Using the methods of RCI and decomposition of the RCI we measured income-related inequities in both visual impairment and the use of eye screening services among type 2 diabetic patients living in Canada. For visual impairment, our results show similar trends to that of general health; i.e., individuals with lower income tend to have more visual impairment than individuals with higher income. Meanwhile, our decomposition analyses for eye screening services indicate "pro-rich" disparities in the use of eye screening services and preventive eye care services, suggesting that more eye screening services are concentrated in type 2 diabetic patients with higher income groups.

The concentration of visual impairment in type 2 diabetic patients with lower socioeconomic status (i.e., RCI negative, pro-poor direction), is not a new or surprising finding. It is commonly believed that income plays a crucial role in determining health (38, 39). For example, Canadians with the highest incomes are two and a half times more likely to report good health than those with the lowest income (40). Similarly, those with upper middle and middle income follow suit with likelihoods of reporting excellent or very good health below their more affluent counterparts. There are various interpretations how inequities in income are translated into health disparities (39-41). One of the interpretations is that health disparities are caused by the differential accumulation of exposures and experiences (39, 41). Under this interpretation, income-related health disparity is an accumulative result of negative exposures and lack of material conditions at the individual level, accompanied by systematic underinvestment across a broad range of human, physical, health, and social infrastructure (39, 41). For example, it is well acknowledged that income disparity in health is significantly associated with various dimensions of infrastructure – unemployment, health insurance, social welfare, work disability, educational and medical expenditure (39, 41).

The decomposition analysis for visual impairment showed that age and marital status were the largest contributors to the existing pro-poor disparities, suggesting that most of the income-related disparities in visual impairment are actually due to the concentration of patients who are older or live alone in the lower tail of the income distribution. However, these factors making large contributions may be difficult to be modified. Firstly, greater age is known as one of risk factors for eye disease such as DR, glaucoma, and cataracts and higher prevalence and severity of these eye complications increase in older age groups (42-44). In addition, lower income is more concentrated in the older age groups because many elderly patients may not be involved in the paid labour force, as shown by the negative concentration index in Table 5.3. Lastly, compared to the younger age group, there should be higher rate of older patients living alone. Considering the major contributions of unmodified factors to overall disparity, the observed disparity in visual impairment may be considered more of an inequality, rather than inequity. Both inequality and inequity indicate differences in health or health care, the latter term implies differences in health that is considered to be unfair or the result of injustice (45).

For the use of eye screening services, the RCI indicated a “pro-rich” direction, suggesting that individuals with higher income were more likely to use regular eye screening services. In the RCI model that only included type 2 diabetic patients with non-visual impairment, we also observed a “pro-rich” direction, indicating that type 2 diabetic patients with higher income were more likely to use preventive eye screening services, even in the absence of diagnosed eye disease. In addition to the observed RCIs, our results indicate that horizontal inequity, referring to unequal service for equal need, exists for patients with diabetes living in Canada. This suggests that inequities in eye screening services remain even after adjusting for need factors among type 2 diabetic patients. Nonetheless, it should be recognized that the magnitude of the RCIs and HIs were relatively small.

Previous studies of income-related inequities in health care using the RCI and decomposition analysis have often found inequities in health care, with the main contributor to the observed inequities being income (34, 46, 47). For instance, a Canadian study found that income-related inequity in the use of health care services exists despite Canada’s universal health care system, suggesting that while the current universal health care system may help to reduce income-related barriers to health care, it fails to eliminate them completely (47). Findings from recent research consistently show that use of specialist services in Canada is more frequent for individuals with higher income (47). McGrail et al. (2008) interpreted the observed inequities in specialist services in Canada to be a result of physician referral patterns because there were no income-based inequalities in the use of General Physician services (47). Studies have shown that a patient’s preference or expectation plays an important role in explaining variation in the use of specialist services between those of high and low SES (48, 49). The poor may be less able to express their need for care. Furthermore, those of higher SES may have different attitudes about the benefits that can be realised by accessing care (49). Regarding use of eye screening services, it is plausible that lower income individuals may not be as aware of the importance of regular screening services.

In our decomposition analysis, income had the largest contribution to disparities in both eye screening and preventive eye screening services. Following income, private health insurance for eye care was the second largest contributor to the existing inequities in the use of these services. The finding suggests that under the current publicly funded health care system in Canada, having private health insurance could be a crucial determinant in the use of eye screening service because eye screening services by an optometrist may not be covered by provincial health care plan. For example, prior to 2007, eye screening services by an optometrist for diabetic patients was not reimbursed by the Alberta provincial health care plan (2). This suggests that an increase in provincial coverage for eye screening services could potentially reduce income-related pro-rich inequities.

Discussion of diabetic complications with health professionals was also an important contributor to eye screening service utilisation. We found that discussion of diabetic complications with a physician was associated with increased the use of eye care services. A qualitative study suggested that detailed information from a primary care provider is a pivotal factor in adherence to recommended eye screening services in diabetes management (50). Because patients acquire the relevant information from their primary care provider, primary care providers have an important role in reducing income-related inequity in eye screening services.

Limitations

While the RCI, and decomposition of the RCI, are a common and widely used method for quantifying the magnitude of inequities in health and health care, we have identified several limitations. Firstly, decomposition analysis is not able to provide causal pathways between the individual determinant and health/health care disparities. Secondly, the decomposition method is a deterministic approach and there could be other factors, not included in our model, that have may contributed to the observed inequities in visual impairment and eye screening services. Although we included age, sex, duration of diabetes, and self-rated health as need factors for eye screening services, there are many other important clinical indicators of need for eye screening services, such as glycemic control and blood pressure. Unfortunately these clinical data are not available with the survey data. In addition, the SLCDC-DM 2011 is a self-reported survey data and therefore prone to measurement errors and biases such as recall and social desirability bias. Given that self-reported rates of regular eye screening services are higher than previous Canadian studies (2, 18), social desirability is quite likely. Another potential limitation is that sampling strategy which may limit the generalizability of findings; for example, residents of three territories and of First Nations reserves were not included in this survey.

5.5. Conclusion

Our findings suggest that disparities in visual impairment and the use of eye screening services were observed among type 2 diabetic patients living in Canada, although these disparities are small in magnitude. In particular, individuals with type 2 diabetes who were of lower income are more likely to have visual impairment; however the magnitude of the RCI is relatively small. The main contributors to the observed disparity were age and marital status, suggesting that the observed disparity could be interpreted as inequality rather than inequity.

Pro-rich disparities in both eye screening and preventive eye screening were found, suggesting that patients with higher income are more likely to receive regular eye screening services. The major contributors to the observed disparities were income, private insurance and patient's experience in discussion their complication with health professionals. This finding suggests that income-inequity in the use of eye screening services among type 2 diabetic patients may still exist under the universal health care system despite the magnitude of inequities were relatively small. To develop health and health care policy for tackling disparities in visual impairment and the use of eye screening services, the identified determinants in our study could be considered.

Tables and Figures

Table 5.1. Visual impairment and eye screening services according household income

Income quintile*	Total estimated number (N)	Visual impairment (%)	Eye screening (%)	Total estimated number (N)	Preventive eye screening (%)
Lowest quintile	96,125	54.0	71.0	44,183	59.2
2nd quintile	249,631	45.1	70.9	137,105	66.1
3rd quintile	334,876	31.6	69.8	228,894	62.0
4th quintile	341,034	27.1	69.8	248,752	62.5
Highest quintile	302,887	23.3	78.0	232,373	75.9
Mean/Sum	1,324,553	32.7	71.9	891,307	65.6

*income quintile groups were categorized based on the household income decile groups defined by Statistics Canada

Table 5.2. Measurement of disparities for visual impairment and eye screening services

Measurement of Disparity	Visual impairment	Eye screening services	Preventive eye screening services
Mean (SE)	0.33 (0.02)	0.72 (0.15)	0.66 (0.21)
Relative Concentration Index (95% CI)	-0.104 (-0.163, -0.046)	0.025 (-0.001, 0.051)	0.043 (0.004, 0.082)
Horizontal Inequity Index (HI)		0.039	0.056

Table 5.3. Decomposition results for visual impairment among type 2 diabetic patients

	Elasticity	CI	Contribution	Total (%)	Aggregated contribution (%)
Sex - Female	0.083	-0.120	-0.010	9.5	**9.5**
Age 50-64	0.129	0.116	0.015	-14.3	**42.0**
Age 65-79	0.348	-0.094	-0.033	31.5	
Age 80 or more	0.121	-0.215	-0.026	24.8	
Duration of DM	0.188	-0.029	-0.005	5.3	**5.3**
Marital status	0.142	-0.188	-0.027	25.6	**25.6**
Lower income	0.051	-0.371	-0.019	18.2	**18.2**
Lower education	-0.072	-0.182	0.013	-12.6	-12.6
Official language at home	-0.126	-0.425	0.011	-10.2	-10.2
Immigrant	-0.009	-0.203	0.002	-1.7	-1.9
Aboriginal	0.004	0.056	0.000	-0.2	
Quebec	0.025	-0.148	-0.004	3.6	-3.9
Ontario	0.111	0.023	0.003	-2.5	
Prairie	0.019	0.074	0.001	-1.3	
BC	0.037	0.104	0.004	-3.7	
Urban/Rural	0.010	-0.050	-0.001	0.5	**0.5**
Private insurance	0.043	0.057	0.002	-2.4	-2.4
Discussion with HP	0.151	0.033	0.005	-4.8	-4.8
Sum				65.4	
Residual				34.6	

Table 5.4. Decomposition results for eye screening services among type 2 diabetic patients

Decomposition	Elasticity	CI	Contribution	Total (%)	Aggregated contribution (%)
Sex- Female	0.021	-0.120	-0.003	-10.2	-10.2
Age 50-64	-0.018	0.116	-0.002	-8.3	-3.7
Age 65-79	-0.004	-0.094	0.000	1.4	
Age 80 or more	-0.004	-0.215	0.001	3.2	
Duration of DM	0.048	-0.029	-0.001	-5.7	-5.7
Visual impairment	0.083	-0.088	-0.007	-29.8	-29.8
Self-health- Good	-0.028	0.031	-0.001	-3.6	-8.3
Self-health- Fair	-0.020	-0.102	0.002	8.5	
Self-health- Poor	0.010	-0.313	-0.003	-13.2	
Sub-Sum			-0.014	-57.7	-57.7
Need factor CI		-0.014			
Marital status	-0.018	-0.188	0.003	**13.6**	**13.6**
Lower income	-0.059	-0.371	0.022	88.2	**88.2**
Lower education	0.000	-0.182	0.000	-0.1	-0.1
Official language at home	0.003	-0.425	-0.001	-5.2	-5.2
Immigrant	0.003	-0.203	-0.001	-2.4	-3.0
Aboriginal	-0.003	0.056	0.000	-0.6	
Quebec	-0.009	-0.148	0.001	5.1	**7.7**
Ontario	-0.002	0.023	0.000	-0.2	
Prairie	0.009	0.074	0.001	2.6	
BC	0.001	0.104	0.000	0.2	
Urban/Rural	0.020	-0.050	-0.001	-4.0	-4.0
Private insurance	0.213	0.057	0.012	49.3	**49.3**
Discussion with HP	0.151	0.033	0.005	20.1	**20.1**
Sub-sum			0.041	166.6	
Non-need factor CI		0.041			
Residual			-0.002	-8.9	
HI (RCI-Need CI)		0.039			

Table 5.5. Decomposition results for preventive eye screening services among type 2 diabetic patients

	Elasticity	CI	Contribution	Total (%)	Aggregated contribution (%)
Sex- Female	0.026	-0.111	-0.003	-6.7	-6.7
Age 50-64	-0.033	0.100	-0.003	-7.8	-12.1
Age 65-79	0.015	-0.099	-0.001	-3.4	
Age 80 or more	0.001	-0.295	0.000	-0.8	
Duration of DM	0.042	-0.013	-0.001	-1.2	-1.2
Self-health- Good	-0.033	-0.004	0.000	0.3	-11.1
Self-health- Fair	-0.022	-0.057	0.001	3.0	
Self-health- Poor	0.016	-0.384	-0.006	-14.4	
Sub-Sum			-0.013	-31.2	-31.2
Need factor CI		-0.013			
Marital status	-0.026	-0.144	0.004	8.6	**8.6**
Lower income	-0.083	-0.382	0.032	73.7	**73.7**
Lower education	0.015	-0.162	-0.002	-5.8	-5.8
Official language at home	0.000	-0.446	0.000	-0.5	-0.5
Immigrant	0.007	-0.253	-0.002	-4.1	-4.5
Aboriginal	-0.002	0.069	0.000	-0.3	
Quebec	-0.017	-0.130	0.002	5.3	**11.6**
Ontario	0.000	-0.019	0.000	0.0	
Prairie	0.014	0.155	0.002	5.0	
BC	0.004	0.145	0.001	1.3	
Urban/Rural	0.025	-0.041	-0.001	-2.4	-2.4
Private insurance	0.254	0.072	0.018	42.8	**42.8**
Discussion with HP	0.042	0.210	0.009	20.6	**20.6**
Sub-sum			0.062	144.2	
Non-need factor CI		0.062			
Residual			-0.006	-13.1	
HI (RCI-Need CI)		0.056			

Figure 5.1. Aggregated contributions to RCI for visual impairment

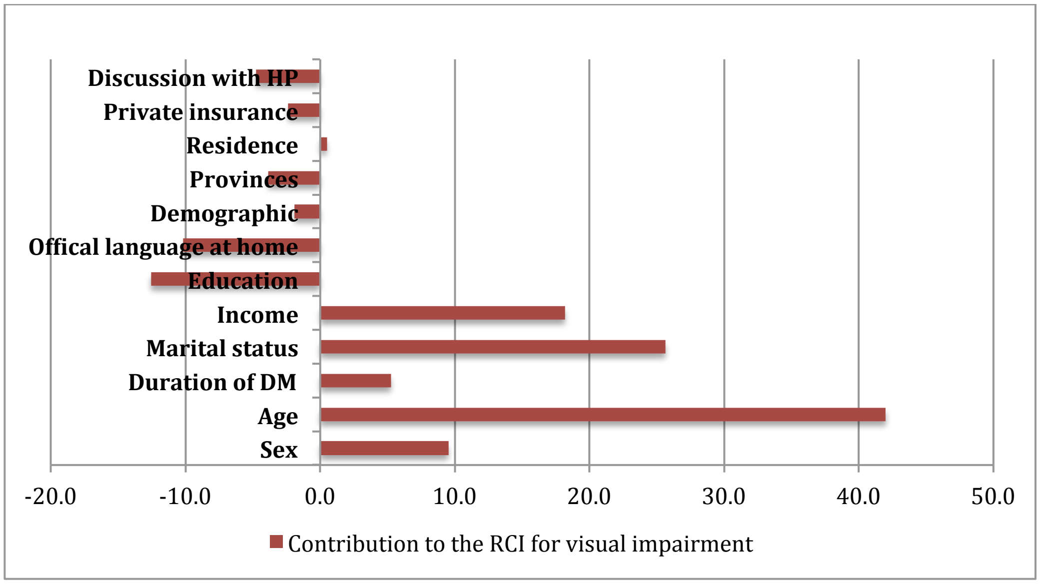


Figure 5.2. Aggregated contributions to RCI for eye screening services

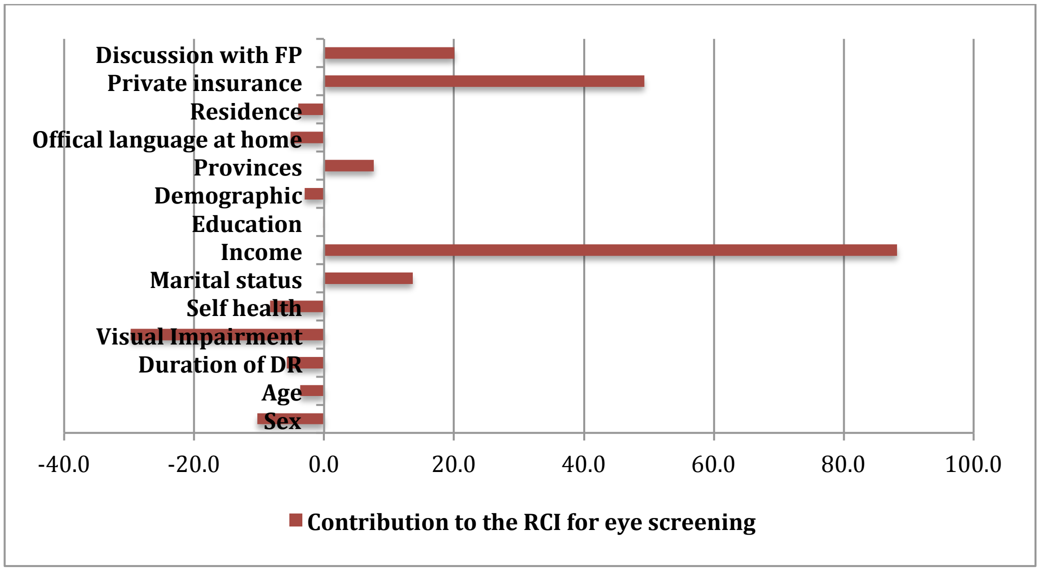
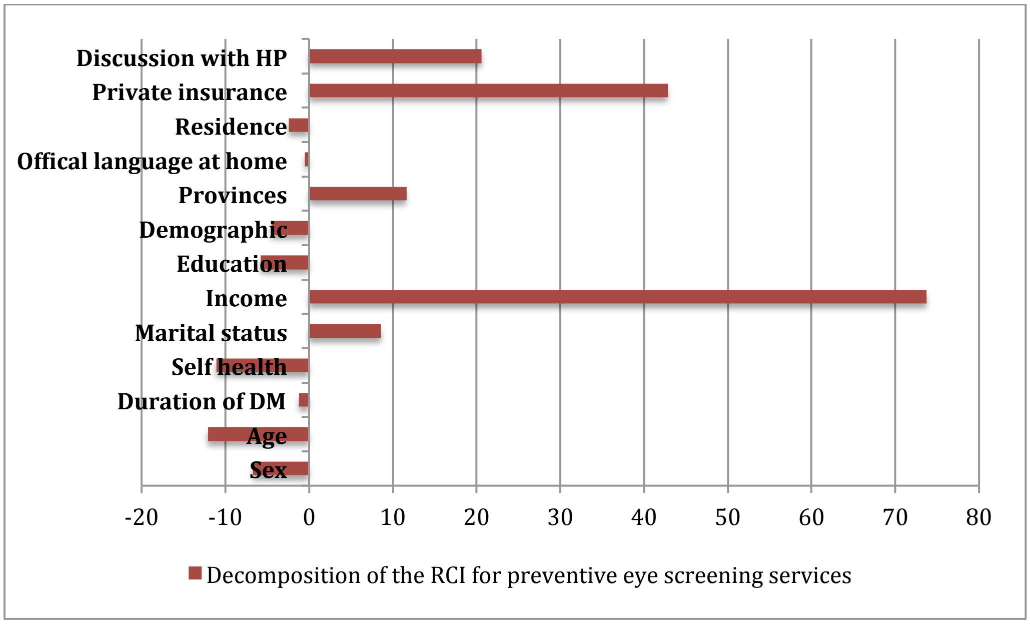


Figure 5.3. Aggregated contributions to RCI for preventive eye screening services



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Chapter 6. Conclusion

6.1. Summary of Research

The findings from this program of research suggest that socioeconomic-related disparities in visual impairment and eye screening services in patients with diabetes exist in Canada. The results of three separate analyses indicated socioeconomic disparities in eye care services at the provincial level and income-related disparities in visual impairment and eye screening services at the national level. However, while they exist, and are measureable with the Relative Concentration Index (RCI) method, the magnitudes of these disparities are quite small when considered at the population level.

Nonetheless, when we explored variations in the disparities using a decomposition analysis of the RCI, a number of important trends were apparent. At the provincial level, the observed patterns of disparity in eye care services varied by socioeconomic indicator: household income and material deprivation indices consistently showed a “pro-rich” pattern, while the social deprivation index indicated a “pro-poor” pattern. Our findings also suggested that material deprivation index and place of residence (urban/rural) were important contributors to the observed “pro-rich” income- and material deprivation index-related disparities. The social deprivation-related disparity was explained largely by social-deprivation itself. At the national level, like at the provincial level, income-related disparities in eye screening services and preventive eye screening services revealed a “pro-rich” pattern while the disparity in visual impairment indicated a “pro-poor” pattern. The main contributor to the observed disparities in both eye screening service and preventive eye screening was income while the disparity in visual impairment was predominantly related to age.

In addition, an examination of socioeconomic factors associated with visual impairment and both general eye screening and preventive eye screening services among Canadians living with diabetes provided further evidence that demographic factors such as age, sex, and duration of diabetes were associated with visual impairment. Regarding eye screening services and preventive eye screening services, in addition to household income, factors such as patient's experience in discussing diabetic eye complications with health professionals and having private insurance covering eye care appointment were associated with more regular eye screening services among diabetic patients.

The observed disparities in eye examination in diabetic populations from this line of research are consistent with findings from health disparity research in the U.K., where a similar publicly funded health care system exists (1-4). For instance, Gulliford and his colleagues reported that diabetic patients residing in most deprived areas were more than 1.4 times as less likely to have received eye screening services compared to those residing in least deprived areas (1). Also, Hippisley-Cox et al. stated that patients in areas of high deprivation were less likely to have retinal screening compared with those from affluent areas (4). These previous findings of disparities in eye examinations were mainly assessed by logistic regression-based analyses, and represented by odds-ratios (ORs). These results can be interpreted as a relative comparison, showing the proportional increase or decrease of relative risk in use of eye examination for a one-unit change in socioeconomic group (5). Meanwhile, our results of disparities from the RCI analyses indicate positive or negative value of the RCI, showing a disproportionate share of eye examination across socioeconomically ranked groups (5).

6.2. Strengths, Significance and Implication of Research

Diabetic retinopathy (DR) has emerged as an important health care priority as DR is the leading cause of blindness and visual impairment among patients with diabetes (6). It has also been estimated that nearly half a million Canadians currently have some form of DR, and approximately 100,000 Canadians have PDR (a more advanced form of DR), diabetic macular edema or both (7). Glaucoma, cataracts, and other disorders of the eye also occur earlier and more frequently in people with diabetes (8). Vision impairment caused by DR can be prevented and more easily managed when the disease is detected and treated early in its course (9-11). Accumulated research suggests that regular eye examination can help to decrease the risk of severe vision loss by >90%, by providing early detection and timely treatment (6, 12). Periodic eye screening also substantially contributes to cost savings. Previous studies have shown that the cost of eye screening services is much less than the costs associated with providing social support for visual impairment (13-15). Partly for this reason, clinical practice guidelines for DR screening established by the Canadian Diabetes Association (CDA) recommend that all diabetic patients receive an annual eye examination (10).

Despite the importance of regular eye examinations for preventing visual impairment in diabetic patients, there is limited Canadian evidence on factors associated with visual impairment and eye screening services in the diabetic population. Consequently, both federal and provincial governments and policy makers may remain unaware of the current magnitude and, more importantly, the potential for rises in diabetic eye diseases and the resulting need for regular eye screening services (8).

To our knowledge, this program of the research, using provincial population datasets and a nationally representative survey dataset, is the first attempt to measure and understand socioeconomic disparities focusing on visual impairment and eye screening services in Canadian patients with diabetes. It is also the first study to identify socioeconomic factors associated with visual impairment and eye screening services in Canada. Our program of research provides evidence on previously unexplored issues in disparities in health and health care in Canadians living with diabetes. While there is a bourgeoning literature on health and health care disparities, most previous studies are based on a macro study of inequity in health or health care. The line of our research focused particularly on visual impairment and eye screening services among diabetic patients, and our micro-level investigation of a specific disease and service category benefits to address the issue of appropriateness or quality in particular health care services (16).

Using provincial surveillance datasets for the past 15 years, we were able to obtain relatively precise estimates and to observe the patterns of the disparities. One of the limitations of current literature is the use of cross-sectional data, which make it difficult to see the pattern of health and health care disparities (17). Our findings from the Alberta Diabetes Surveillance System (ADSS), using data from 1995-2009, allowed us to observe changes in disparities across different socioeconomic indicators and infer how changes of provincial health policy might impact on changes in health and health care disparities in diabetic patients living in Alberta.

In addition, to enhance our ability to understand disparities in eye care services at the provincial level, we linked the ADSS, the provincial surveillance dataset, to different socioeconomic indicators. The ADSS datasets includes household income and the Canadian Deprivation Index, which are derived from the 2006 Canada Census. Household income, reflecting material goods and services, is widely used in research and considered a standard measure of socioeconomic status (18). Nevertheless, while income is a "gold standard" indicator of health and health care and has ramifications for other determinants of health, it cannot take the place of the other determinants (19). To take the multidimensional concept of socioeconomic status into account, deprivation indices were developed and are widely used in the U.K., Europe, and Canada (20). The material deprivation index used in our study represents the level of educational attainment (i.e., percentage of secondary school completion), employment status, and income (20). The social deprivation index mainly reflects the prevalence of single-parents families, of people living alone, and of those who are separated, divorced or widowed (20).

Our findings suggest that economic indicators, represented by income and material deprivation, indicate "pro-rich" disparities in use of eye care services, with a slightly larger magnitude of material deprivation-related disparities compared to income-related disparities. This finding implies that material deprivation index might capture more economic or different dimension of economic-related factors than does income alone. Previous study has documented that material deprivation, measured by the economic exclusion index, is not captured by income alone, suggesting that income may be an insufficient indicator of socioeconomic condition (21).

On the other hand, when based on the social deprivation index, disparities were in the "pro-poor" direction: the opposite indicated by income- or material deprivation-related RCI. This counterintuitive finding might be explained by previous finding (22), suggesting that retired patients might use more health care services because they would focus more time and attention on their health. Alternatively, the fact that there are more socially deprived areas in urban setting, where more ophthalmology services are available, could help explain the "pro-poor" direction of social deprivation-related RCI. In our descriptive analysis of the distribution of social deprivation ranks across the province, the lower social deprivation ranks were more concentrated in Edmonton and Calgary. It is therefore plausible that a large number of individuals residing in more socially deprived neighbourhood in urban areas could more easily access eye care services, and this may result in a "pro-poor" direction of social deprivation-related RCIs. As a result, social deprivation may not be a strong predictor of the use of eye care services. In fact, it has been suggested that all component of social capital may not be related to use of health care services due to the complex nature of social capital (23).

The RCI and decomposition analysis are now widely accepted by international organizations such as the Organisation for Economic Co-operation and Development and World Bank in studies measuring socioeconomic disparities (24-28). In addition, these analyses are considered a standard quantitative measure of health and health care disparities and can be used in studies to provide policy evidence to alleviate existing health and health care disparities (5, 29). We adopted these methods for our research to assess disparities in eye care services and visual impairment. The concentration index has proven to be a useful summary statistic in the measurement of socioeconomic disparities in the health sector and is accompanied by a relatively straightforward graphical representation of disparities. This simplicity allows the comparison of different time periods and facilitates an understanding of disparities by policy makers and other stakeholders. Although using the RCI method strengthens our research, our interpretation of the results focused on the magnitude of the RCI. In general, the observed degree of the RCI can be interpreted based on absolute values (16, 24, 30-33); however, the value of the RCI from the line of our research is relatively small. A number of Canadian studies have reported similarly small magnitude of disparities in specialist care (16, 32-34). In addition, the studies from the U.K. and several European countries have also exhibited disparities in health and health care of similar magnitudes (24, 35). These common findings support our conclusion that the magnitude of socioeconomic-disparities in health and health care within a publicly funded health care system could be very small, suggesting that socioeconomic barriers to health care within such a system are alleviated, but are not completely eliminated.

To set a health policy priority, it may be meaningful to compare the RCIs for different health issues. For example, a recent Canadian study on oral health that also used the RCI method based on the same CCHS data and self-reported household income, reported a magnitude of the RCI (0.26) larger than the RCI for we observed for visual impairment in diabetic patients (0.11) (36). This direct comparison might be taken to mean that the disparity in oral health in the general population may be a bigger priority than the disparity in eye care services or visual impairment for diabetic patients in Canada. Nonetheless, as with most policy discussions, there are other considerations that should be taken into account in priority setting, including the absolute number of individuals affected, and the economic considerations in establishing strategies to ameliorate the disparities.

This line of research program was initiated based on integrated knowledge translation approach in order to support an identified knowledge gap of concern to the clinical community. The underuse of recommended eye examination was initially identified as an increasing concern in Alberta Diabetes Atlas 2011 (9). Dr. Chris Rudnisky, a co-author of the Alberta Diabetes Atlas 2011 was engaged to investigate this line of research program in addition to Dr. Jeffrey Johnson and Dr. Sara Bowen. The collaboration with Dr. Rudnisky has enriched our research capacity, particularly in understanding provision of eye care services in real clinical settings in addition to clinical information on eye complications among patients living with diabetes.

6.3. Limitations, and Implications for Future Research

Although we were able to add to the growing evidence assessing socioeconomic-related disparities in eye screening services and visual impairment using a state-of-the-art econometric approach, there were a number of limitations to our research that further studies could address.

Firstly, using both provincial administrative data and national survey data limits our ability to accurately capture the existing socioeconomic disparities due to some degree. For instance, provincial administrative data allows us to identify all individuals diagnosed with diabetes and their use of ophthalmology services, but individuals who have not accessed the provincial health care services are not included, potentially underestimating the magnitude of socioeconomic disparities in the use of eye care services among individuals with lower socioeconomic position.

In addition, the provincial datasets did not include eye-screening services by optometrists, because provincial health policy did not allow reimbursement of costs for these services until the end of 2007. Yet, as reflected in the current Canadian Diabetes Association guidelines, diabetic patients should receive eye screening services for DR from an experienced eye care specialist, including both ophthalmologists and optometrists (9, 37). The lack of data on eye screening services by optometrists may bias our estimate of disparities in the use of eye screening services, exaggerating the degree of the disparities. For example, the exclusion of patients who used optometry services might have led to overestimation of the RCI and horizontal inequity index in chapter 2 and 3. Since eye screening services by optometrists has been covered by the Alberta's provincial health care plan since 2007 (9), future research should aim to capture the services provided by optometrists in order to accurately measure disparities in eye screening services in the diabetic population. Regarding the SLCDC data, a nationally representative survey data, we observed that the rate of eye screening was higher than the rate from our provincial data. The higher rate of eye screening services in the SLCDC data may simply reflect the fact that individual were asked if they received an eye screening service by either ophthalmologists and optometrists while the provincial data only capture the eye screening services by ophthalmologists. However, it needs to be considered that the SLCDC is a survey data that may have patient's recall bias and non-response bias.

Moreover, as we included all services provided by ophthalmologists in the analysis of data from the ADSS, we did not differentiate screening from treatment, hence we referred to disparities in "eye care services". In our analysis of the SLCDC data, we attempted to differentiate preventive eye screening services by limiting our analyses to those individuals reporting no visual impairment. Future research using administrative data and looking separately at optometrist and ophthalmologists' services may be better suited to differentiate screening and treatment, respectively.

Secondly, we were unable to determine if the observed disparities in eye screening services were a result of access or utilization using the national survey data. While "access" and "utilization" are used interchangeably, these terms should be distinguished (38, 39). Access is a matter of supply only, utilization is a function of both supply and demand (39). As such, equity of access can be achieved by providing some services to patients rather than taking the patients to the services (39). In contrast, utilization of healthcare services implies not only access but also an individual's perception of the benefits of health care (39). For instance, individuals may not fully understand the benefits of health care, and fail to use the services although they can easily access the services. This subject requires further attention and quantitative and qualitative methods could be used to answer this question.

Thirdly, being limited to using provincial health care administrative datasets and a national survey data, we were unable to determine individual's clinical need and appropriateness of the eye care and eye screening services received or not received. In our decomposition analyses and logistic regression, we only included age, sex, duration of diabetes and self-rated health (the SLCDC analyses only) as predictors of eye health and eye care (screening) services in diabetic patients. However, there could be other important clinical indicators associated with eye health and eye care (screening) services. Unfortunately, our data were limited to the administrative database and the self-reported survey dataset, which lack information on these important clinical parameters. For a better understanding of disparities in diabetic population, future study needs to use data including clinical information.

Finally, we were not able to fully explain the opposing patterns of the RCI for material deprivation and social deprivation in the analyses based on ADSS data. One possible explanation for the different direction of social deprivation-related RCI is the independence of the material and social deprivation indices. The material and social deprivation indices were constructed with principal component analysis (PCA) and applying a varimax rotation in order to improve readability and to make these two factors independent (20). The scoring used for PCA results in the material deprivation index and social deprivation index being uncorrelated (20). Still, the lack of correlation does not explain the opposite relationship between the material deprivation- and social deprivation-related RCI over time in the province as a whole. Further study is required to understand the opposite relationship between these two different deprivation-related disparities.

6.4. Conclusions

Identifying the roots of inequities is a primary goal of public health. It is imperative that action on the causal factors causing inequities be undertaken. Our research results provide Canadian evidence on disparities in visual impairment and eye screening services in diabetic patients at both provincial and national levels. Through two separate analyses using provincial administrative datasets, we observed “pro-rich” economic disparities in use of eye care services in Alberta, and “pro-poor” social disparities in eye care services in Alberta. These disparities were explained mainly by the material deprivation and social deprivation index, respectively. In our analyses using a national survey data, we also observed a “pro-rich” direction of income-related disparities in both eye screening services and preventive eye screening services. In addition, we found a “pro-poor” direction of income-related disparity in visual impairment among type 2 diabetic patients. The main contributors to the observed income-related disparity in visual impairment were demographic factors such as age, sex, and marital status. For income-related disparities in eye screening services and preventive eye screening services, enabling factors in addition to income were the patient’s experience in discussing diabetic complication with a health professional and having private health insurance coverage for eye care appointments. To understand causal pathways on this topic, further research is required using both provincial and national datasets as well as using qualitative methods.

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