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Socio-Economic Status and Diabetes: Disease Burden, Clinical Profiles and Quality of Care

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled “Socio-Economic Status and Diabetes: Disease Burden, Clinical Profiles and Quality of Care” submitted by Doreen M. Rabi in partial fulfilment of the requirements of the degree of Masters of Science.

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Abstract

Rationale: Socio-economic status is recognized as a determinant of health. A strong association between economic and/or social deprivation and illness has been consistently demonstrated by several researchers. Several factors are likely mediating this relationship including biologic factors, behavioural and psycho-social factors, and factors relating to health care access.

Individuals of low economic standing have been shown to be at higher risk for diabetes and diabetes related complications. However, little is known about the factors mediating this relationship.

Objectives: The objective of this thesis is to examine and characterize some of the factors mediating between income and health outcomes among those with diabetes. To this end, three sub-studies were performed to determine: 1) The association between median household income and diabetes prevalence; 2) The association between median household income and referral to diabetes care; 3) The association between median household income and vascular risk factor burden among patients with diabetes; and 4) The association between median household income and the burden of coronary atherosclerosis among patients with diabetes.

Methods: This thesis drew on several data sources including a diabetes education centre patient registry, the Alberta Health and Wellness diabetes surveillance database, the Alberta Provincial Project of Heart Outcome Assessment in Coronary Heart disease (APPROACH) database and Statistics

Canada Census 2001 data. Descriptive statistics and regression models (uni- and multi-variate) were employed to describe and characterize the association between income and outcomes.

Results: These studies revealed the following: 1) Low income is associated with a higher diabetes prevalence; 2) Low income is associated with an appropriately higher rate of referral to diabetes care; 3) Low income is associated with a higher burden of vascular risk factors; 4) High income is associated with significantly less coronary atherosclerosis.

Conclusions: This thesis research sheds light on some of the factors that may mediate the association between income and health outcomes. Future research is now needed to explore interventions that may address outcome disparities related to income.

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Chapter 1: Rationale and Overview of Thesis

1.1 Introduction

This chapter is a global introduction to this thesis that examines the association between income status and health outcomes among patients with diabetes. In this section, concepts central to this document will be reviewed including diabetes mellitus and socio-economic status (SES). The association between SES and health outcomes will be introduced and a conceptual model that explores the mediators of this SES/ health outcomes relationship will be introduced. The research reported in this thesis will directly inform this conceptual model and the sub-studies that comprise this thesis will be outlined.

1.2 Diabetes Mellitus

Diabetes mellitus is a chronic metabolic disorder that results from the body's inability to make insulin in the pancreas, or from the body's inability to use endogenous insulin efficiently. The incidence and prevalence of diabetes has increased dramatically over the last several decades. In 1985, the absolute burden of diabetes cases world wide was estimated to be 30 million. In 2000, the World Health Organization and International Diabetes Foundation estimated that there were now 177 million cases of diabetes world wide and estimate that number to rise to 300 million by 2025 (1). In Canada, diabetes is highly prevalent affecting approximately 5% of the population (2).

In the absence of optimal metabolic control, diabetes can lead to numerous vascular complications including retinopathy, nephropathy, neuropathy and cardiovascular diseases (3-5). Diabetes remains the leading cause of adult onset blindness, end stage kidney disease and non-traumatic amputation. Over 60% of patients with diabetes will succumb to the complication of ischemic heart disease or stroke (4). As a result, diabetes is extraordinarily costly to our society both in terms of direct costs to the medical system and the indirect costs of disability and premature mortality (2;6).

1.3 Associations between Diabetes and Socio-Economic Factors

There is increasing evidence that the incidence of diabetes is increasing most quickly in the developing world (7). Within developed, industrialized nations, we are seeing that diabetes risk in not evenly distributed across society but that it is the lowest income groups that appear to be most vulnerable. Data from Canada, the United States and the United Kingdom suggest that diabetes may be up to 2 times more common among the lowest income groups compared to the highest (8-11). The reason for this gradient is unclear. It has been shown that lower income groups have more risk factors for diabetes including obesity, sedentary lifestyles and diets low in fresh fruits and vegetables(8-10;12-14). However, even after controlling for the inequitable distribution of risk factors, this association between low income and diabetes remains significant (10).

1.4 Socio-Economic Status

Before exploring potential mechanisms that underlie this association between SES and health outcomes, we must first acknowledge that SES is a complex construct. Socio-economic standing involves one's income and educational experiences, housing status and social standing. The interaction between SES and an individual is quite dynamic and is not a simple exposure. Some, like Barker, have proposed a "critical period" hypothesis which asserts that there is one point in time at which exposure to economic and social disadvantage will result in an increased risk for poor health outcomes (15). Others have postulated and demonstrated that there is a clear exposure response to low income. The longer one lives in relative poverty, the higher their risk of poor health outcomes (16). The third suggestion is that one's risk depends on how one maneuvers on the social ladder through life (17;18). If one is born into social advantage and they maintain that social status throughout life they will be at low risk. However, if they are born into advantage but fail to keep that status, their risk for poor health outcomes will increase as the fall through the social strata. Conversely, an individual who is born into poverty but rises through the social ranks will experience a reduction in risk as a result of this migration.

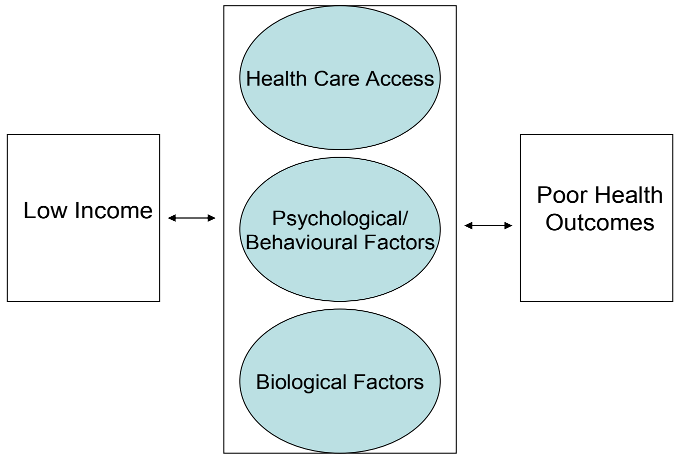
1.5 Socio-Economic Status and Poor Health Outcomes

Low income and low social standing are associated not only with an increased diabetes risk, but an increased risk for several other poor health outcomes as well. In patients with diabetes, complications are more likely to occur among those with low income. Booth and Hux demonstrated that, even within a universal health care system, the least affluent patients were admitted to hospital 43% more often than the wealthiest patients(19). Cardiovascular complications are also more prevalent among lower socio-economic strata. Heart disease was 3.6 times higher among those reporting low educational attainment compared to those with the highest levels of education (20) . Weng and colleagues revealed in their analysis of a British cohort that low socio-economic standing was associated with a significantly higher risk diabetes-related microvascular complications. They found that neuropathy and nephropathy were over 2 times more common among those living in the most socially deprived areas of London (21).

1.6 Conceptual Model of Thesis

How income and social standing influence health outcomes is not clear. What is clear is that there are likely several mediating factors. Figure 1 illustrates this relationship and outlines the conceptual model upon which this thesis is based.

Figure 1.1 – Conceptual Model of Thesis



This conceptual model is original to this thesis but was product of the following evidence:

Health Care Access

Even within universal health care systems, access to medical care may not be equitable across income quintiles (20;22-24). In Canada, there is evidence to suggest that while primary care may be well accessed by low income groups, the wealthy are more effective at accessing specialty care. Roos and colleagues demonstrated in an analysis of administrative data, that low income patients visit their primary care physician more often then wealthy patients. Surprisingly, they also found that the poorest patients were also more likely to be admitted to hospital with ambulatory care sensitive conditions such as asthma (25). Similarly, Dunlop found that patients from low socio-economic strata were nearly

2 times more likely to visit their primary care physician, but were half as likely to be referred for specialty care (26). Alter and Pilote have both demonstrated that the wealthy are more likely to receive timely angiography (24;27). Alter also demonstrated that the wealthy were more likely to receive ongoing specialty cardiac care and rehabilitation. Singh also suggests that the wealthy are more likely to receive preventative care. In their study, Singh and colleagues showed that the wealthy were 38% more likely to receive colorectal screening and/or investigation than the least wealthy patients (28).

Psychosocial Factors

Psychosocial factors have also been linked to income and poor health outcomes. Depression, like diabetes is more prevalent among the poor and is also associated with poor health outcomes (29-31). Marmot, in the Whitehall Study, and others, have demonstrated that feelings of control (mastery) in the workplace were negatively associated with cardiovascular risk (32;33). Personality factors such as aggression and hostility have been found to be more prevalent among low income groups and linked to adverse health events (34;35).

There is increasing appreciation for the role of one's social environment. A lack of social network or supports is known to be associated with an increased risk for adverse outcomes (36). Similarly, the contextual socio-economic status, or the socio-economic status of one's environment, is also associated with poor outcome. Malmstrom elegantly demonstrated that irrespective of educational status, residence in a neighbourhood with high deprivation scores was associated with poor health (37). Similarly, Winkleby and colleagues demonstrated that even after controlling for individual income, educational and employment status, neighbourhood socio-economic status remained an independent predictor of mortality (38).

Behavioural Factors

As previously mentioned, there are recognized socio-economic gradients in the prevalence of many health-related behaviours. Sedentary lifestyles, obesity, and smoking prevalence have been found to be inversely related to economic status (12-14).

Biologic Factors

Physiologically, low income is considered analogous to a chronic physical stress. Low income appears to trigger many on of the neuro-hormonal changes seen with other stressful stimuli. The hypothalamic-pituitary-adrenal (HPA) axis appears to be responsive to various aspects of the SES construct. This endocrine axis, whose stimulation results in the production of the hormone cortisol, is a significant component of the body’s “fight or flight” response. In studying the Whitehall cohort, Kunz-Ebrecht and colleagues found that serum cortisol levels were inversely related to job stress, and in particular, perceived control in the work place (39). The CARDIA study also found in their analysis of young adults, that both low income and education levels were associated with an abnormal cortisol response. Cortisol generally peaks shortly after waking and then decreases throughout the day. Cohen and colleagues found that social disadvantage was associated an attenuated waking cortisol response and higher levels of cortisol the remainder of the day (36) . This flattening of the usual diurnal variation in cortisol is thought to lead to a number of the metabolic and immune abnormalities that might predispose to adverse health outcomes (40). Chen and colleagues have found that low SES is associated with elevated interleukin-5 and interferon gamma responses. Similarly, it has also been shown that markers of inflammation such as C-reactive protein and homocysteine are higher among low income populations (41;42).

Other physiologic differences have been noted across income groups that likely influence the risk for adverse health events, particularly cardiovascular mortality. Some specific differences in lipoprotein (i.e. cholesterol) levels have been described. Certain lipoprotein particles, like low density lipoprotein (LDL-c) and triglycerides, are known to increase one's risk for atherosclerosis and heart disease. Total serum cholesterol levels and triglycerides appear to be inversely related to socio-economic status. Low levels of high density lipoprotein (HDL-c) are an established risk factor for atherosclerosis and higher levels are thought to be protective (43-46). There has been some suggestion that HDL may be positively associated with income (13;14;47).

1.7 Outline of Thesis Content

This document details studies examining the association between income and health outcomes among patients with diabetes. It is important to note that in this thesis, an area level income measure, median household income per dissemination area, will be used. The use of neighbourhood level income as a proxy for individual level SES is common in health research, but this approach to inferring individual income has been questioned by some, as in the past some large studies note discordance between an individual's income and their neighbourhood income. Some, like Southern and colleagues and Sin et al. (48;49) found the agreement between these 2 measures rather low, however, others like Krieger and colleagues, and Diez Roux et al. have found better levels of agreement (50;51). Despite this imperfect agreement between individual and area based measures, area and individual income measures perform very similarly in predicting a variety health outcomes, particularly cardiovascular mortality (50-52). Furthermore, there is an increasing appreciation of the importance of one's social context and how this is associated with disease risk. Winkleby and Cubbin illustrated that residence in a low SES neighbourhood confers additional risk for mortality beyond that predicted by individual level income alone (38).

In this thesis, we will examine some of the factors that mediate this relationship between income and health outcomes among patients with diabetes. In sub-study A (chapter #2) we attempt to determine if there are differences in ability to access health care among income groups. Specifically, we explore how income is associated with diabetes prevalence and access to a centralized diabetes care centre. In sub-study B (chapter #3); we seek to see if there are biological differences between income groups with respect to the burden of coronary risk factors. In this study, we examine whether the clinical profiles of patients referred for diabetes care differ across income quintiles. In sub-study C, (chapter #4) we further explore whether there are biological differences at an anatomical level. Here, we examine whether there are differences in the burden of coronary atherosclerosis across income groups.

Together, these sub-studies will draw on a variety of data sources and will inform us on some of the factors that may be mediating the association between income and health outcomes among patients with diabetes. Specifically, they will shed light on whether differential access to care exists and may result in differing health outcomes across social classes. They will inform us of potential clinical and biologic differences across economic groups and whether these may be an instrument in determining health outcomes. These sub-studies will also provide insights into potential behavioural differences across groups that may also be mediating between income and health outcomes.

Global Statement of Thesis Purpose

This thesis attempts to examine several factors that may mediate the relationship between low income and adverse health outcomes among patients with diabetes. To this end, three sub studies will be performed that draw on a combination of data sources. This thesis has the following objectives:

1) To determine if there is an association between median household income and diabetes prevalence.
2) To determine if there is an association between median household income and access to specialty diabetes care.
3) To determine if there is an association between median household income and clinical profiles at the time of referral for diabetes care.
4) To determine if there is an association between median household income and burden of coronary artery atherosclerosis.

CHAPTER 2: The Association of Median Household Income with Diabetes Prevalence and Access to Diabetes Care (Thesis Sub-study A)

2.1 Background

Among patients with diabetes, low socio-economic standing is associated with an increased risk for heart disease and cardiovascular related mortality and an increased risk of microvasculopathy (20;53). Booth and Hux demonstrated in a Canadian cohort that low income was a significant predictor of hospitalization for acute glycemia related complications (19).

Diabetes is an ambulatory care sensitive condition (54). This implies that the complications of diabetes are theoretically preventable with optimal ambulatory care. Therefore access to diabetes care is extremely important to those with diabetes. Indeed, Shah and Zgibor have independently illustrated that among Canadian and American cohorts of diabetes patients, a history of specialist diabetes care was associated with significantly better glycemic control as measured by haemoglobin A1C (55;56).

Little is known about how individuals with diabetes access ambulatory care. The influence of wealth on health care access and utilization of health care services, however, is an area of active research. Even within publicly funded and universally accessible systems, there is evidence that individuals from lower socio-economic groups have impaired access to care reflected in longer wait times and fewer referrals for specialist care (26;27). This might contribute to the observation of worse health outcomes, such as the increased rate of acute diabetic complications seen in the Booth study (19), in lower income populations.

The present study is a unique examination of how SES relates to not only diabetes prevalence, but also access to diabetes care. While previous studies have documented the socio-economic gradient in diabetes prevalence and other studies have documented disparities in utilization of health care services, the present study is unique in its simultaneous examination of *both* burden of disease and utilization of health care services. We sought to determine 1) the prevalence of diabetes across income quintiles, 2) the population rates of referral to diabetes care across income quintiles, and 3) the proportion of referrals to diabetes education across income quintiles among those with diabetes. This combination of information provides unique insights into the complex interplay of burden of disease, SES and health care service use.

2.2 Methods

Data Sources

This study used a regional Diabetes Education Centre (DEC) database that captures basic demographic information on all attendees to the regional clinic situated in Calgary, Alberta, Canada whose population is approximately 1 million. The sampling frame was all active patients at the DEC from May 1, 2000 to

January 9, 2002. The sample consisted of 4247 patients. All sampled patients included were from a single health region within the province of Alberta. The DEC under study is the single regional provider of diabetes education services. Access is dependent upon physician referral to the centre.

Diabetes prevalence data were obtained from the Alberta Ministry of Health and Wellness which maintains a population-based diabetes surveillance system. The Alberta surveillance system forms part of a National Diabetes Surveillance System. This system is based on administrative data and uses validated case definition algorithms to capture cases of diabetes (57;58).

Neighborhood income, education and age data were obtained from Statistics Canada Census data (2001). We defined a neighborhood as equivalent to a census dissemination area (DA). A DA is a small geographic area covered by a single census data collector and typically containing 400-700 persons. Median household incomes per DA, number of residents over the age of 65 years per DA, and number of individuals with university level education per DA were calculated. These data, along with the NDSS diabetes prevalence data were merged with the DEC database on the variable DA.

Derivation of Income Quintiles

Household income quintiles were generated from DA annual income data. Each quintile contained 274 or 275 DAs. The income brackets for each quintile were as follows in Canadian dollars: quintile 1= $\leq$ \$42781, quintile2= \$42782-\$54080, quintile 3= \$54081-\$64880, quintile 4= \$64881-\$81017, and quintile 5 = $\geq$ \$81018.

Study Variables and Analysis

Using the merged data sources, we were able to determine the following proportions: 1) The population rate of diabetes per DA (number of diabetes cases per DA/DA population); 2) the population rate of DEC referral (referral count per DA/DA population); 3) the proportion with diabetes referred to the DEC (referral count per DA/diabetes cases per DA).

Other ecologic variables were explored as possible confounders. We calculated the proportion of residents with a university level education (number of respondents reporting university education per DA/DA population) as level of education is associated with income and may be inversely associated with risk for diabetes. We also determined the proportion of elderly per DA (number of respondents reporting age over 65 years/DA population) as increasing age is associated with increased risk for both low income and diabetes.

Chi square analyses were used to determine if diabetes prevalence or population rates of referral differed across income quintiles. We used Poisson regression to determine the relationship between neighborhood income, education level, and age with diabetes prevalence and referral to the DEC, controlling for education level and age. The unit of analysis in this multivariate analysis was the DA.

All statistical analyses were performed in STATA, version 8.

2.3 Results

Population, number of diabetes cases and number of referrals by household income quintile are shown in Table 2.1. This table also includes the diabetes prevalence, population rate of DEC referral and the proportion with diabetes referred to the DEC per income quintile. Table 1 illustrates that diabetes cases ($\chi^2 = 743.72$, $p < 0.0005$) and referrals for diabetes care ($\chi^2 = 168.435$, $p < 0.0005$) were more frequent in the lower income quintiles. Referral among those with known diabetes, however, appears to be uniform across income quintiles with approximately 14% of patients with diabetes being referred to the DEC in the two year period studied. Income quintile 4 (second highest income quintile) was incidentally noted to have lower rate of referral in comparison to the other income groups ($\chi^2 = 73.9095$, $p < 0.0005$).

Table 2.1 Characteristics of Income Quintiles

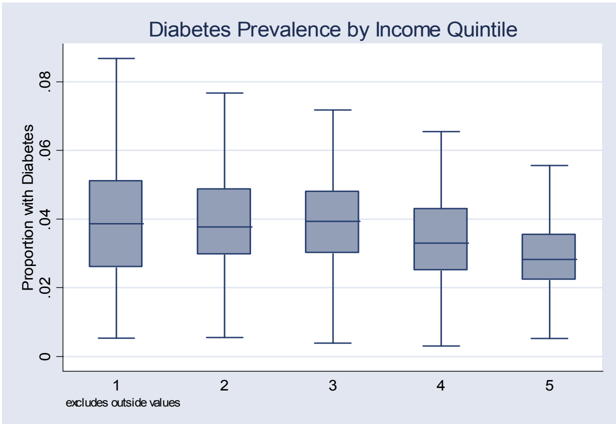
Income Quintile	Population	DA Count	DM Cases	Number of referrals	Diabetes Prevalence* (percent)	Population rate of referral** (per 1000)	Proportion with diabetes referred§ (percent)
1 (lowest)	157 020	274	6521	926	3.9	5.3	14.5
2	163 485	275	6501	859	3.7	5.6	14.2
3	174 010	274	7049	907	3.9	5.6	14.2
4	214 630	274	6956	805	3.3	4.4	13.6
5 (highest)	219 010	274	6243	788	2.8	4.1	14.3

* Median diabetes prevalence per DA
**Median population rate of referral per DA
§ Median proportion with diabetes referred per DA

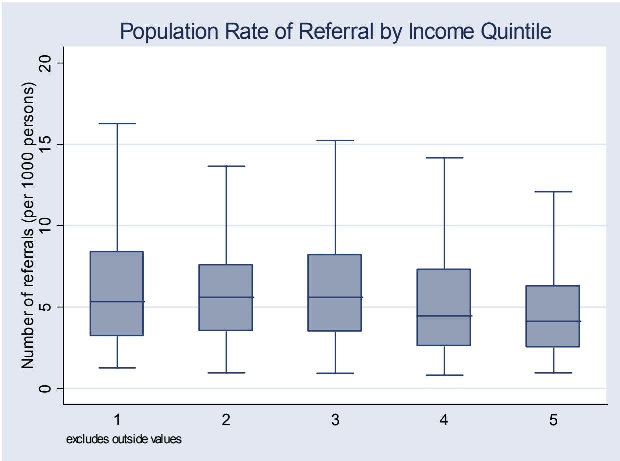
Figure 2.1 (Panel A) illustrates a box plot of diabetes prevalence across income quintiles. A socio-economic gradient is noted with the highest prevalence of diabetes in the lowest income quintiles (3.9%) and the lowest prevalence in the highest quintile (2.8%). Figure 2.1 (Panel B) shows the population rate of referral across income quintiles. Again, a gradient in referral is seen with the lowest quintiles having the highest rates of referral (5.3 – 5.6 per 1000 people) and the wealthy quintiles having lower rates of referral (4.1-4.4 per 1000 people). Figure 2.1 (Panel C) demonstrates the apparent uniformity of referral among those with known diabetes, with the proportion referred in this population remaining at approximately 14%, irrespective of income quintile.

<u>Figure 2.1</u>: Box plots of diabetes prevalence by income quintile (panel A), population rates of DEC referral by income quintile (panel B), and proportion referred to the DEC among people with diabetes (panel C).

Panel A



Panel B



Panel C

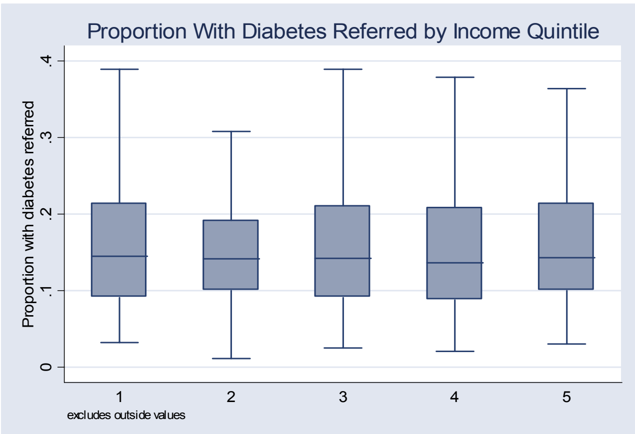


Table 2.2 shows the results of the Poisson regression analysis for diabetes prevalence. This analysis reveals that the lowest income quintiles (quintiles 1, 2 and 3) had significantly higher rates of diabetes than the upper quintiles (quintiles 4 and 5). In comparison to the highest income quintile, income quintile 1 (< $42781) had a 13% higher risk of diabetes, income quintile 2 ($42782-$54080) had a 10% higher risk of diabetes and income quintile 3 ($54081-$64880) had a 15% higher risk of diabetes. Neighborhood education and age were also found to be significantly associated with diabetes risk. These latter findings indicate that if a hypothetical neighborhood had only university graduates, it would have a 78% lower rate of diabetes compared to a neighborhood with no university graduates. Similarly, in a hypothetical neighborhood with only elderly residents- the risk for diabetes would be 8 times higher than if all of a neighborhood's residents were less than 65.

Table 2.2- Poisson Model for Diabetes Prevalence

	Rate Ratio	**95% Confidence Interval**	***p*-Value**
Income Quintile			
1 (lowest)	1.13	1.09-1.17	<0.0005
2	1.1	1.06-1.14	<0.0005
3	1.15	1.11-1.19	<0.0005
4	1.01	0.97-1.04	0.722
5 (highest)	1.0 (reference)		
University Education	0.22	0.20-0.25	<0.0005
Age > 65	8.23	7.32-9.26	<0.0005

The results of the multivariate analysis examining population referral to the DEC are illustrated in table 2.3. Again, lower income quintiles (quintiles 1, 2 and 3) experienced a significantly higher rate of referral to the DEC compared to upper income quintiles (quintiles 4 and 5). Compared to the highest income quintile, income quintile 1 had a 33% higher rate of referral, income quintile 2 had a 28% higher rate of referral and income quintile 3 had a 31% higher rate of referral. Education was not found to be significantly associated with population rate of referral, but there was a significant association with age (RR=7.62 for age>65).

Table 2.3- Poisson Model for Referral to the Diabetes Education Centre among the General Population

	Rate Ratio	**95% Confidence Interval**	***p*-Value**
Income Quintile			
1 (lowest)	1.33	1.2-1.48	<0.0005
2	1.28	1.15-1.42	<0.0005
3	1.31	1.18-1.45	<0.0005
4	1.06	0.96-1.18	0.228
5 (highest)	1.0 (reference)		
University Education	0.86	0.63-1.17	0.332
Age > 65	7.62	5.52-10.52	<0.0005

Table 2.4 presents the results of the multivariate analysis examining referral to the DEC among the population, controlling for prevalence of diabetes. In this model, no significant differences were found with respect to referral for diabetes

care. Advanced age was predictive of a referral rate 2.4 times higher than a younger reference neighborhood. This association was present independent of income. Education, meanwhile, was not significantly associated with referral. Burden of diabetes was significantly associated with referral such that for every additional case of diabetes within a DA, there was a 1.4 % increase in the rate of referral (RR= 1.014, 95% CI 1.013-1.015).

Table 2.4- Poisson Model for Referral to the Diabetes Education Centre, Controlling for Diabetes Prevalence

	Rate Ratio	95% Confidence Interval	*p*-Value
Income Quintile			
1 (lowest)	1.07	0.96-1.18	0.21
2	1.05	0.94-1.17	0.372
3	1.05	0.95-1.17	0.319
4	1.05	0.95-1.16	0.345
5 (highest)	1.0 (reference)		
University Education	1.19	0.87-1.61	0.276
Age > 65	2.39	1.70-3.37	<0.0005
Diabetes Cases	1.014	1.013-1.015	<0.0005

2.4 Discussi*on*

SES & Diabetes Prevalence

These findings demonstrate that neighborhoods with low income have a higher prevalence of diabetes than do wealthy neighborhoods. This socio-economic gradient in diabetes prevalence has been shown previously across studies and across cultures (8-11;49-51). The link between income and diabetes risk is complex. It has been speculated that the increased diabetes risk seen in low income groups is related to the increased prevalence of obesity within this group. It has already been clearly shown that low SES is associated with a much higher prevalence of obesity, especially among women (10;12;59).

Obesity remains a potent risk factor for the development of diabetes; however, low income has been shown to be an independent risk factor for the development of diabetes among women - even after controlling for body mass index and physical activity level (10). Alternatively, low SES could be a result of diabetes in so far that disability related to diabetes complications may limit work and educational opportunities.

Neighbourhood and community level factors also contribute to the increased diabetes risk seen in low income populations. The “built” environment has been shown to be a clear barrier to physical activity in poorer neighbourhoods. Low income communities have been shown to have less biomass and park-space compared to wealthier communities (60). There may also be a perception that it is less safe to walk in a poorer neighbourhood - this not only deters physical activity but erodes the sense of community among residents (61;62). This sense of community, along with established social networks, has been shown to be protective against certain negative health outcomes (61).

SES and Diabetes Care Utilization

Previous studies examining the association of income on access and/or utilization of health care services have suggested that even within single payer systems such as Canada's, access may not be universal. Dunlop and colleagues showed that poor individuals are more likely to visit their family physician, but that the wealthy are nearly twice as likely to be referred on to specialty care (26). The wealthy are also likely to have a shorter wait time for procedures such as coronary angioplasty (27).

Consistently reaching therapeutic targets in diabetes usually requires the support of a multidisciplinary team (diabetes educators, registered dieticians, and social worker and diabetes medical specialists) and the use of several medications. Diabetes education centers allow patients to access the relevant health care professionals and education services within a single centre (63). Previously, little was known about how individuals access such diabetes care services in this centralized model of care, particularly in relation to that individual's socio-economic standing.

The present study shows that people in the lowest income strata were more likely to be referred for structured diabetes education and care. Our study shows that low income patients are approximately 30% more likely to be referred to this DEC and that this seems to appropriately reflect burden of disease.

SES and Utilization of Diabetes Care Controlling for Prevalence of Diabetes

Our unique ability to study DEC access while also knowing prevalence of diabetes indicates that referral of patients with diabetes is quite consistent across income quintiles. Therefore, the utilization gradient seen truly reflects disease burden and implies that there is no access bias based on income. This is a positive finding but somewhat surprising in light of a history of studies suggesting that less affluent individuals have impaired access to care. We speculate that increasing patient awareness of the “diabetes epidemic” (64) may be leading to more patients requesting referral. It is also possible that the DEC may be viewed as an extension of primary care. Low income populations have a higher burden of health problems in general, and the primary care physicians who serve these communities may view the DEC as the most efficient way to provide complex patients (i.e. those with diabetes) with the care they require. Given the finding of Dunlop and Roos (25;26) of good access to primary care for lower income individuals, it is perhaps not that surprising that less affluent patients who are visiting their family physician frequently are also accessing the DEC.

It is established that among patients with diabetes, low income patients are at increased risk for adverse health outcomes. This study would indicate that differential access to care is not a significant factor influencing poor outcomes among these patients. However, there may be process of care issues that may be a factor but were not addressed in this study. Primary care physicians’ threshold for referral, for example, warrants further examination. While we did not see a socioeconomic gradient in overall access to the DEC, we cannot exclude the possibility that wealthy individuals may have been referred earlier and with less co-morbid disease.

This study is limited by its cross-sectional nature. We also examined the association of SES and referral in the context of a centralized model of diabetes care. Our findings, while applicable to the health region and period under study, may not be indicative of how services are utilized elsewhere. It should be noted that the city under study is relatively wealthy. Only 6% of this study population lived at or below the national poverty line. However, post-hoc analyses demonstrated that while there was a higher prevalence of diabetes among those who live in poverty, access to diabetes care was not significantly different to those with higher income. This study also examined data aggregated to the level of dissemination area. While finding that low income was associated with diabetes and referral to diabetes care, we cannot say that it was indeed the lowest income individuals in these neighborhoods that were the most likely to have diabetes or to be referred. Finally, the validity of using neighborhood income as a surrogate for individual level income has been called into question by previous studies as this measure is not always consistent with individual level income (49;51). There is emerging evidence, however, that neighborhood-level income is in and of itself an independent SES construct that is a valid predictor of health outcomes, over and above any effect relating to individual income (38;50;52).

In spite of these limitations, the present study provides encouraging data that diabetes care services are being accessed and utilized by those who require it. This study involved a unique combination of several data sources, and with this richness of data was able to show that while diabetes may be more prevalent in lower income quintiles, these individuals are as successful at accessing diabetes care services as their wealthier counterparts.

CHAPTER 3: Association of Median Household Income with Clinical Profiles of Patients Referred for Diabetes Care (Thesis Sub-study B)

3.1 Background

It is well established that individuals with low income are at increased risk for the development of diabetes (9;12;65). Among those with a diagnosis of diabetes, low income is an independent predictor of hospitalization related to the acute complications of diabetes and is associated with a higher odds of microvasculopathy and heart disease (19;20;53) . While it has been speculated that this increase risk of complications among the economically disadvantaged may reflect differential access to specialty diabetes care, there is increasing evidence in the literature (65) and in the previous sub-study, that there is not an access bias related to income when it comes to diabetes care.

If indeed access to specialty care is not related to an individual's economic status, why are we seeing poorer outcomes among less wealthy patients? Clearly there are factors beyond access to care mediating this finding. Previous researchers have demonstrated that health related behaviours are linked to socio-economic status. Wealthy patients are known to be leaner, are less likely to be sedentary and are less likely to smoke (66). The wealthy have also been noted to have higher HDL-c levels which are known to be protective against the development of atherosclerosis (13;14;47). However, with the exceptions of body weight and body mass index (BMI), differences in clinical and cardiac risk factor profiles across income quintile, in patients with diabetes, have not been well characterized (9;10). Furthermore, little is known about potential differences in the utilization of evidence based preventative therapies across income quintiles.

The objective of the present study is to determine if there are clinical differences in patients referred for diabetes care relative to income. This study seeks to determine if clinical profiles (including medication use) differ based on income for a population of diabetes patients being referred for care in an urban diabetes education centre.

3.2 Methods

Data Sources

This study used a regional Diabetes Education Centre (DEC) database that captures basic demographic information on all attendees to the regional clinic situated in Calgary. The sampling frame was all active patients at the DEC from May 1, 2000 to January 9, 2002. The sample consisted of 4687 patients. All sampled patients included were from a single health region within the province of Alberta. The DEC under study is the single regional provider of diabetes education services. Access is dependent upon physician referral to the centre. The postal codes of patients registered in the DEC database were linked to their corresponding dissemination area using the Statistics Canada Postal Code Conversion File (PCCF).

Neighborhood income data were obtained from Statistics Canada Census data (2001). We defined a neighborhood as equivalent to a census dissemination area (DA). A DA is a small geographic area covered by a single census data collector and typically containing 400-700 persons. Therefore, median household income per DA was the income measure used in this study. These data were merged with the DEC database on the variable DA.

Derivation of Income Quintiles

Household income quintiles were generated from DA annual income data. Those residing in a DA with a median household income of $40877 or less were assigned to income quintile 1 (n= 940). The neighbourhood incomes ranged from $40878-$53065 in quintile 2 (n=937), from $53066-$62921 in quintile 3 (n=936) and from $62922-79828 in quintile 4 (n=938). The highest income quintile, quintile 5, included those that resided in a DA with a median household income of $79829 or greater (n=936).

Study Variables and Statistical Analyses

Physicians referring patients to the diabetes education centre complete a standardized referral form that includes clinical data. This information was then entered into the DEC patient registry. Clinical information examined in this study included: serum hemoglobin A1C (HBA1C, a commonly used measure of glycemic control); serum lipid profiles including levels of low density lipoprotein (LDL-c), high density lipoprotein (HDL-c) and triglyceride; microalbumin to creatinine ratios (a screening test for diabetes related renal injury) and medications used at time of referral. Upon presentation to clinic- a height and weight are measured by diabetes nurse educators and these measures were used to calculate the body mass index (BMI) which was then entered into the DEC database.

Potential differences in continuous clinical parameters (age, body mass index, duration of diabetes, serum lipid levels, hemoglobin A1C and microalbumin to creatinine ratio) across income quintiles were examined using regression models. If inspection of the distribution of these variables suggested a linear relationship between income and the variable of interest, then income quintile was modeled as a single, categorical predictor variable. If the relationship did not clearly appear linear, then regression was performed using dummy variables in the following equation:

$y = \beta_0 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x5$

Where y = dependent variable

B_0= the intercept

X_2= Inclusion in income quintile 2

X_3= Inclusion in income quintile 3

X_4= Inclusion in income quintile 4

X_5 = Inclusion in income quintile 5

β_i= the B-coefficient for each of the income quintile dummy variables.

Covariates considered in these models included sex and medication use.

Differences in medication use across income quintiles were examined using Chi square analyses.

All statistical analyses were performed in STATA, version 8.

3.3 Results

Descriptive Analysis

Clinical characteristics of patients referred for diabetes care and education are listed, by income quintile, in Table 3.1. The median age of patients increased as income level decreased. The median age in the highest income groups (quintile 5) was 55.27 years compared to the lowest income group (quintile 1) which was almost 2 years older at time of referral with a median age of 56.95 years. There was a similar inverse relationship between income level and BMI. The median BMI in the wealthiest quintile (quintile 5) was 28 compared median BMIs of 29.6 in quintile 1 and 29.8 in quintile 2. The lowest income quintile may be presenting to clinic at a later point following diagnosis of diabetes. The median duration of diabetes was 4 years in the lowest quintile, compared to 3 years in all of the other income groups. In terms of diabetes specific clinical parameters, patients did not appear to differ significantly across groups in with respect to serum LDL-c levels. Patients in the highest income quintile had the highest HDL-c. An inverse relationship between income and triglycerides is suggested as the median triglyceride levels range form 2.40 mmol/L in the lowest income group down to 2.12 mmol/L in the highest income group. Glycemic control may be slightly better in the highest income group as evidence by a median HBA1C of 8.4% in quintile 5 compared to a median HBA1C of 8.9% in all other income groups. There is also a suggestion of a negative association between microalbumin creatinine ratio (M:C) and income. The lowest income group had a median M:C of 2.3 compared to a median M:C of 1.5 in the highest income group.

Table 3.1: Clinical Profiles at time of referral by income quintile

	Income Quintile				
	1 (low)	**2**	**3**	**4**	**5 (high)**
Clinical Characteristic	Median (IQR)				
Age (in years)	56.95 (22.9)	56.52 (21.48)	56.95 (19.94)	55.24 (19.44)	55.27 (18.5)
BMI	29.6 (8.6)	29.8 (8.3)	29 (7.9)	29.5 (8.2)	28 (7.2)
Duration of Diabetes (in years)	4 (9)	3 (8)	3 (10)	3 (9)	3 (7)
LDL-c (mmol/L)	3.01 (1.26)	2.97 (1.1)	3.02 (1.22)	2.97 (1.23)	2.99 (1.26)
HDL-c (mmol/L)	1.12 (0.41)	1.1 (0.36)	1.09 (0.37)	1.1 (0.36)	1.15 (0.35)
Triglycerides (mmol/L)	2.40 (1.88)	2.29 (1.99)	2.41 (2.0)	2.32 (1.76)	2.12 (1.61)
HBA1C (%)	8.9 (3.7)	8.9 (3.7)	8.9 (3.5)	8.9 (3.7)	8.4 (3.3)
Microalbumin: Creatinine	2.3 (9)	1.95 (7.7)	2.4 (7.1)	1.6 (5.9)	1.5 (5)

Boxplots illustrating the distribution of clinical characteristics are illustrated in figures 3.1-8.

Figure 3.1- Box-plot of the distribution of age at time of referral over income quintile

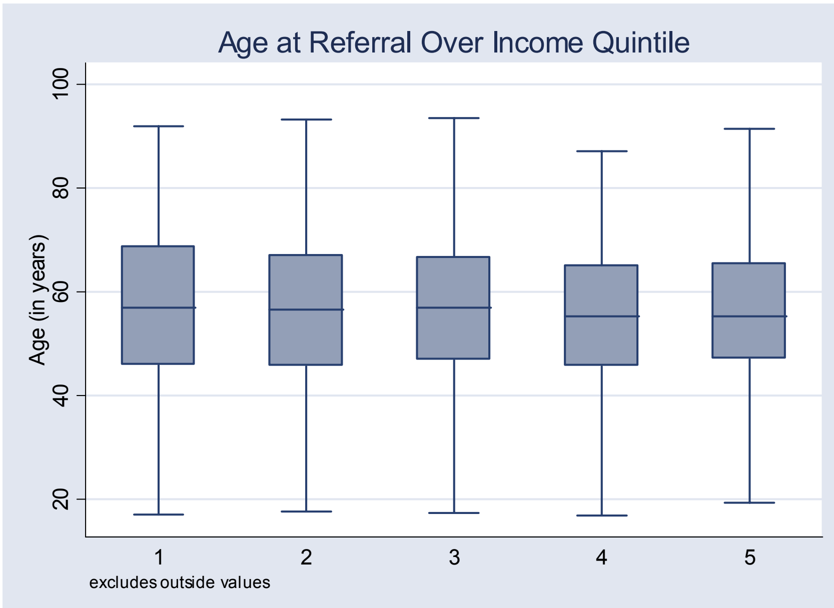


Figure 3.2- Box-plot of the distribution of Body Mass Index (BMI) at time of Referral over Income Quintile

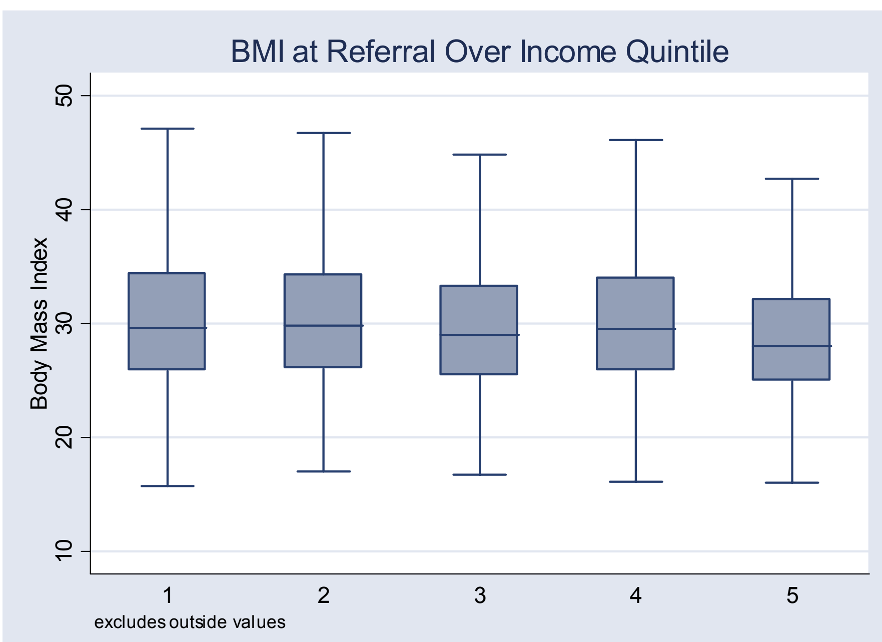


Figure 3.3- Box-plot of the distribution of duration of time (in years) at time of referral over income quintile

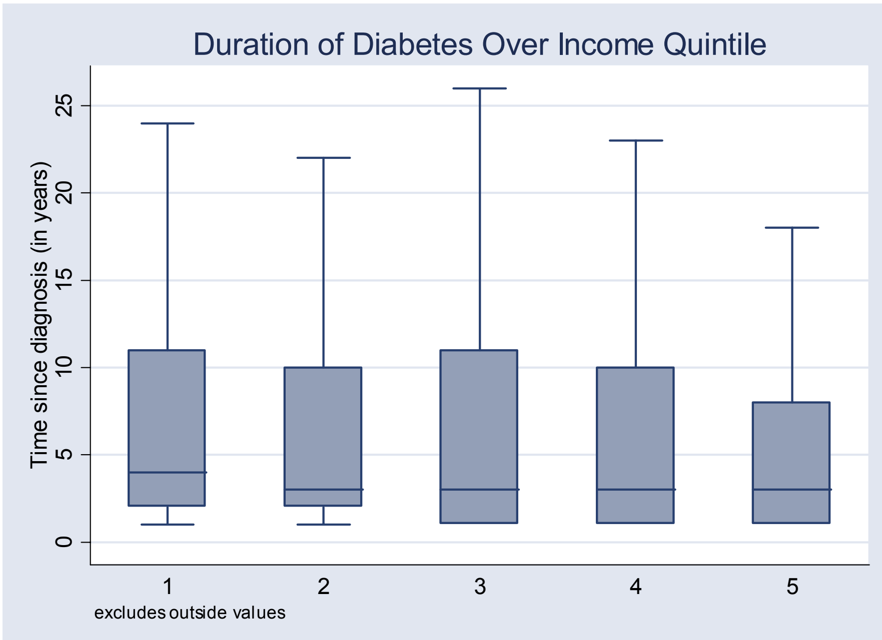


Figure 3.4- Box-plot of the distribution of hemoglobin A1C (HBA1C) at time of referral over income quintile

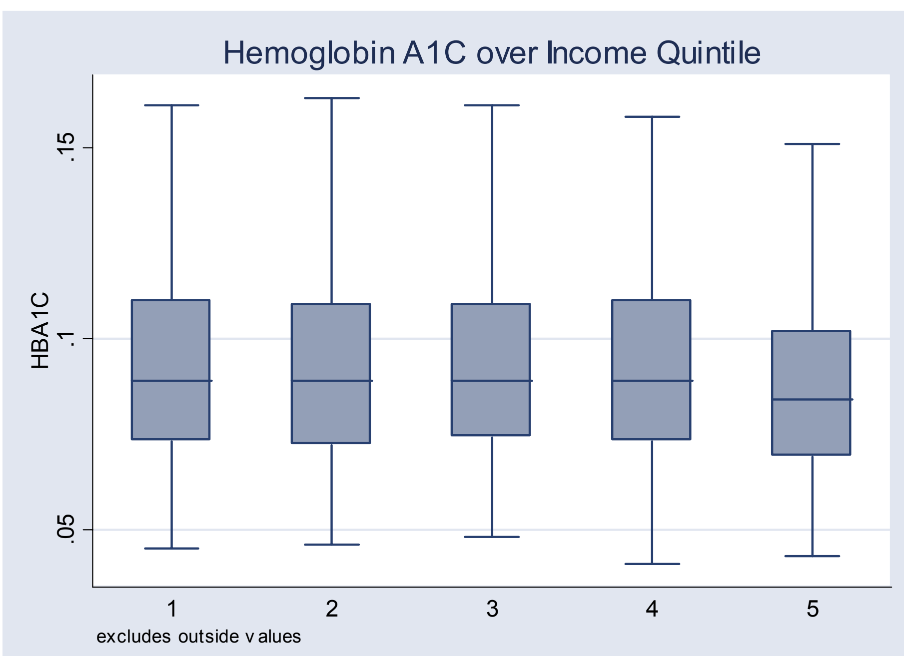


Figure 3.5- Box-plot of the distribution of low density lipoprotein (LDL-c, in mmol/L) at time of referral over income quintile

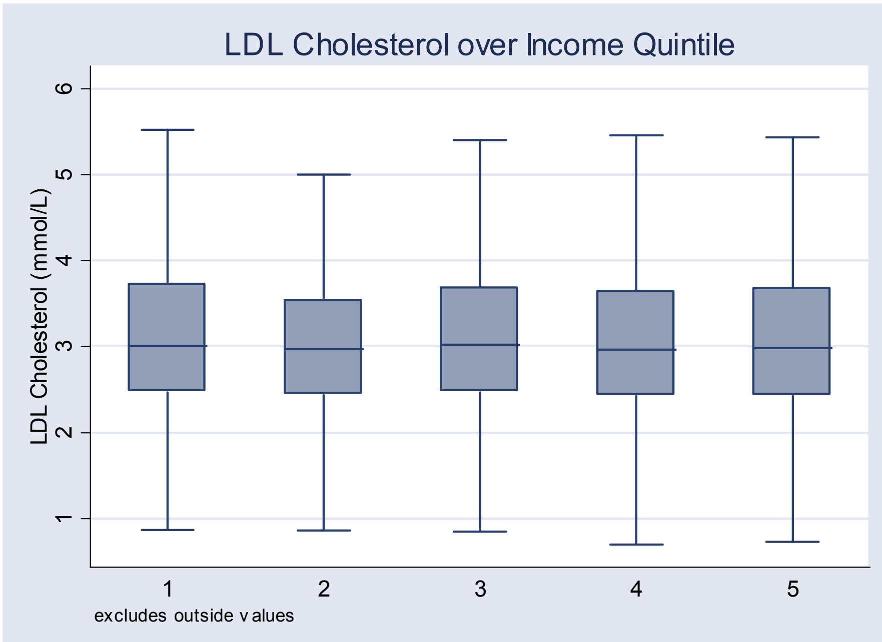


Figure 3.6- Box-plot of the distribution of high density lipoprotein (HDL-c, in mmol/L) at time of referral over income quintile

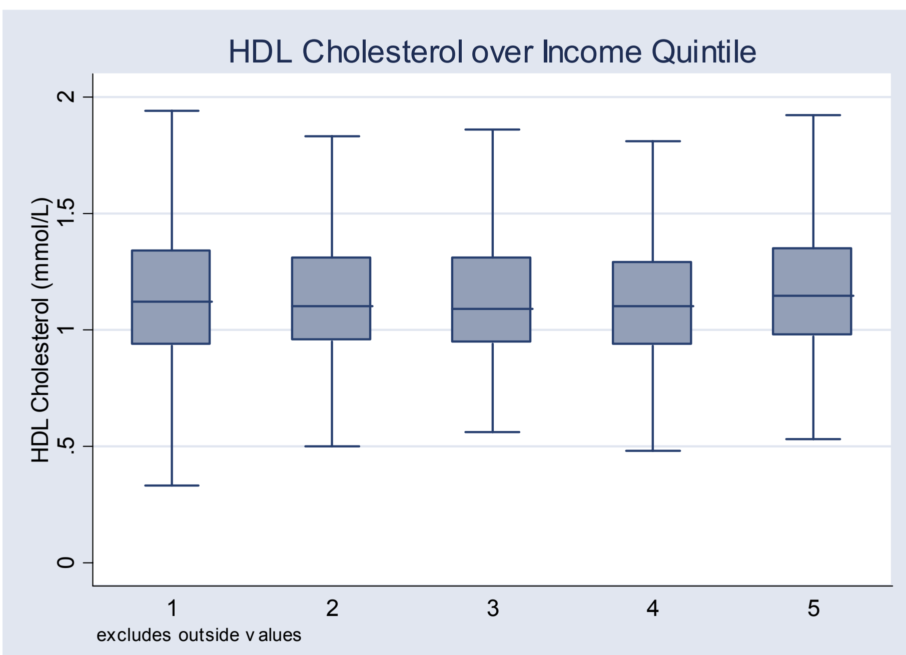


Figure 3.7- Box-plot of the distribution of triglycerides (in mmol/L) at time of referral over income quintile

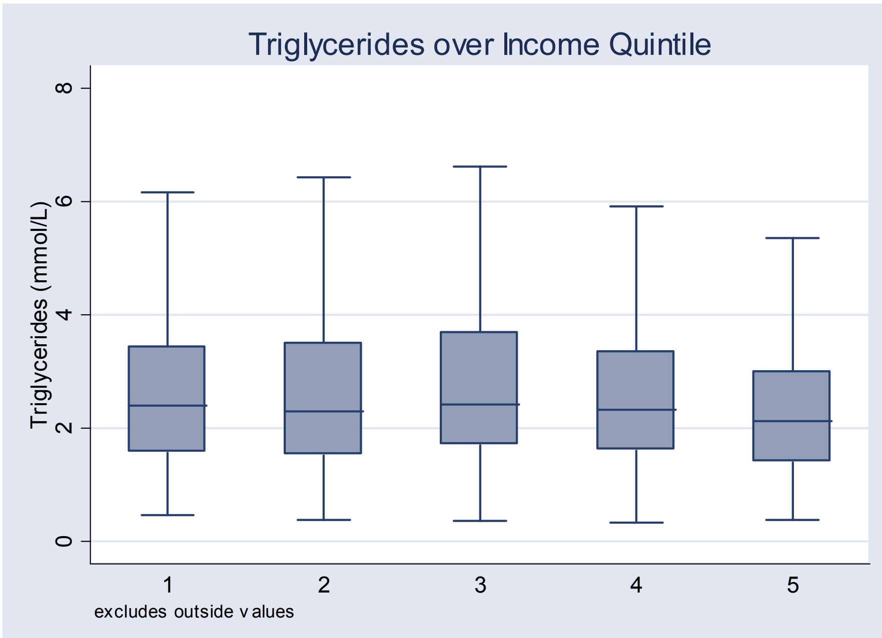
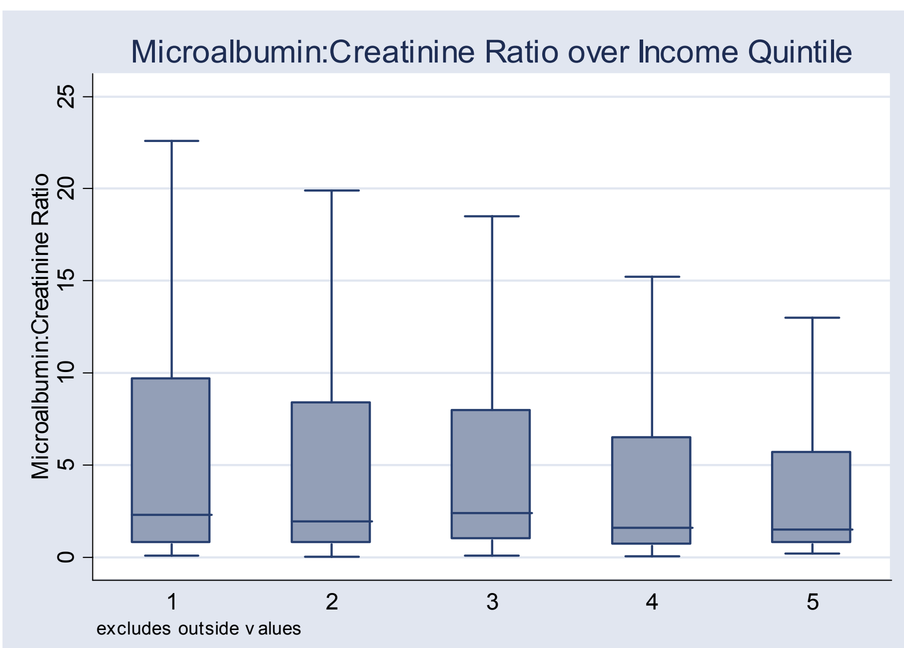


Figure 3.8- Box-plot of the distribution of microalbumin to creatinine ratio at time of referral over income quintile



Regression Analysis

Visual inspection of the distribution of the variables age, body mass index (BMI), and duration of diabetes (Figures 3.1, 3.2 and 3.3), suggested a linear relationship between those clinical characteristics and income. Linear regression (see Table 3.2) indeed demonstrated a significant negative association between age at the time of referral and median household income per DA (β-coefficient = -.339, 95% CI -0.65- -0.03). A similar negative association was noted between BMI at time of referral and income where the β-coefficient was found to be -.362 (95% CI -0.51- -0.21). This relationship remained significant even after controlling for age and diabetes medication use. These findings reveal that wealthy patients presenting for diabetes education are younger and leaner than those from the lower income groups. While this might suggest that the wealthy are presenting earlier in the course of their diabetes, we found no association with income and the duration of diabetes (β-coefficient=-.0167, 95% CI -1.32- 1.29).

Table 3.2: Association of Income Quintile with General Clinical Parameters

Clinical Characteristic	Co-variate	B-coefficient (p-value)	B-coefficient- adjusted for sex (p-value)	B-coefficient- adjusted for sex, age & therapy (p-value)
Age	Quintile	-.339 (0.032)	-.361 (0.023)	
BMI	Quintile	-.362 (<0.0005)	-.319 (<0.0005)	-.306 (<0.0005)
Duration of DM	Quintile	-.0167 (0.980)	.0272 (0.968)	

Visual inspection of the distribution on the clinical variables of LDL-c, HDL-c, triglycerides, HBA1C and microalbumin: creatinine ratio did not reveal an obvious linear relationship with income (Figures 3.4-3.8). In this instance, regression modeling was done by comparing each individual income quintile to a pre-defined reference group, income quintile 1. Table 3.3 lists the results of the analysis. No significant association was found between income and level of glycemic control as measured by HBA1C. After controlling for age, sex, and differences in the use of anti-diabetic medications, the highest income quintile had a trend towards a significantly lower HBA1C. Similarly, while a significant association was not found with respect to microalbumin: creatinine ratio, the box plot of this variable (Figure 3.8) certainly suggests that the highest income groups have lower ratios.

The association of serum lipid levels at the time of referral was also examined. While no relationship was found between the levels of LDL-c with income quintile, significant findings were noted with respect to HDL-c and triglyceride levels. In the unadjusted analysis, HDL-c was highest in the wealthiest income quintile but this did not reach statistical significance. After adjusting for differences in sex, age and use of lipid lowering medications, the association strengthened and became significant. Triglyceride levels were similarly lowest in the highest income groups, this was significant both in the unadjusted and adjusted analyses.

Table 3.3: Association of Income Quintile with Diabetes-related Clinical Parameters

Clinical Parameter	Income Quintile	B- coefficient - Unadjusted (p-value)	B-coefficient – Adjusted (p-value)*
HBA1C	1 (reference)		
	2	.0126 (0.798)	.015 (0.76)
	3	.0625 (0.201)	.063 (0.20)
	4	.0151 (0.757)	.021 (0.67)
	5	.0756 (0.120)	.084 (0.09)
LDL-c	1 (reference)		
	2	-.0813 (0.222)	-.086 (0.193)
	3	-.010 (0.885)	-.016 (0.805)
	4	-.0391 (0.540)	-.044 (0.488)
	5	-.022 (0.731)	-.025 (0.691)
HDL-c	1 (reference)		
	2	-.013 (0.52)	-.01 (0.6)
	3	-.018 (0.35)	-.009 (0.64)
	4	-.014 (0.46)	-.001 (0.95)
	5	.031 (0.11)	.05 (0.008)
Triglycerides	1 (reference)		
	2	-.23 (0.40)	-.22 (0.43)
	3	-.05 (0.86)	-.06 (0.84)
	4	-.26 (0.34)	-.28 (0.31)
	5	-.63 (0.019)	-.68 (0.011)
Microalbumin: Creatinine	1 (reference)		
	2	-8.56 0.058	-8.97 (0.047)
	3	-2.88 0.540	-2.43 (0.602)
	4	-7.58 0.097	-7.16 (0.116)
	5	-6.99 0.122	-7.01 (0.119)

*Adjusted for age, sex, and therapy (HBA1C was adjusted for anti-hyperglycemic medication use, LDL-c, HDL-c and Triglycerides were adjusted for lipid-lowering therapy use and Microalbumin: creatinine was adjusted for anti-hypertensive medication use.)

The proportions of patients on therapy are listed in Table 3.4. Chi square analyses indicate socio-economic gradients with respect to the use of certain diabetes therapies. A statistically significant gradient was noted with respect to the use of diet alone to manage diabetes. In the lowest income quintile, 14.4% of patients presented on diet alone, compared to 24.4% in the highest income group (X^2 = 44.22, p<0.0005). When it came to the use of oral diabetes medication, however, an inverse gradient was noted. Metformin was used by 37.3% of patients in the lowest income group, compared to 30% in the highest income group (X^2 = 18.85, p=0.001). Similarly, sulfonylureas were more commonly used in the lower income quintiles compared to the highest income quintiles (X^2 = 25.63, p<0.0005). No significant associations were found in the use of glucosidase inhibitors (X^2 =2.99, p=0.558), thiazolideindiones (TZD) (X^2 = 2.93, p=0.087) or subcutaneous insulin (X^2 =2.56, p=0.392) and income quintile.

Table 3.4: Association of Income with Medical Therapy Use

	Income Quintile					*P*-value
	1 (low)	2	3	4	5 (high)	
Therapy						
Diet Only	14.1%	14.4%	16.9%	18.8%	24.4%	<0.0005
Metformin	37.3%	36.1%	37.0%	31.5%	30.0%	0.001
Sulfonylureas	29.6%	30.1%	29.3%	24.1%	22.4%	<0.0005
Glucosidase Inhibitors	2.0%	1.3%	1.8%	2.0%	1.2%	0.558
TZD	3.9%	3.5%	4.1%	4.2%	3.5%	0.886
Insulin	19.8%	18.2%	18.3%	18.6%	17.2%	0.688
Lipid Lowering Medication	11.8%	9.0%	9.3%	9.6%	11.0%	0.212
Anti-Hypertensive Medication	19.7%	21.7%	19.0%	19.7%	19.0%	0.596

3.4 Discussion

Diabetes is considered the prototypic ambulatory care sensitive-condition (54). This implies that the complications of diabetes are theoretically preventable with ongoing ambulatory care to facilitate the expedient management of known vascular risk factors such as chronic hyperglycemia, hypertension and hyperlipidemia. While it is unclear whether there is equitable access to primary care for all individuals with diabetes, there appears to be equitable access to specialty diabetes care. However, a socio-economic gradient exists with respect to the risk for complications. This study suggests that this may be due in part to clinical differences of patients at the time of referral. Wealthy patients referred for diabetes care presented to clinic at a younger age, with a lower BMI and with a less atherogenic lipid profile. Furthermore, wealthy patients are overall using less medication compared to their lower income counterparts. Wealthy patients may be at lower risk for complications because they are presenting to specialty clinic with lower risk profiles.

This study, while noting some significant differences in clinical profiles across income quintiles, also provides some reassurance that these differences are not due to frank under-treatment of the economically disadvantaged. The lowest income groups were using more sulfonylureas and metformin compared to the wealthiest groups. Even the use of more costly therapies such as thiazolideindiones and lipid-lowering therapies were similar across income groups. One could argue that the relatively higher triglyceride levels among the lowest income groups may have warranted an equally higher use of lipid-lowering therapies. However the median triglyceride levels of all income groups were, practically speaking, only modestly above therapeutic target (67), again suggesting that these groups are treated in a similar fashion.

While a significant association between income and HBA1C was not noted, inspection of the distribution of HBA1C certainly suggests a trend towards a lower HBA1C in the highest income quintile. High income is frequently associated with higher health literacy and a greater ability to apply health-related knowledge (68;69). It should be noted that while we did not find that HBA1Cs differ significantly at the time of referral, others have documented that individuals from higher socio-economic strata are more likely to experience significant lowering of their HBA1Cs after assessment at diabetes clinic (68;69). It would be most interesting to know had the clinical profiles of these patients been re-evaluated 1 year following their referral whether the differences noted would have remained the same, been attenuated or perhaps been even more pronounced due to differences in health literacy.

While we did not find a significant difference with respect to the duration of the diagnosis of diabetes at the time of referral, examination of the distribution of this variable certainly suggest that this may, in part, be mediating some of clinical differences noted. The wealthiest patient group was also younger, and more likely to be controlled with diet alone- suggestions that these patients may be presenting at an earlier point in the natural history of their diabetes. If wealthy patients were being referred earlier, this may also help explain the inverse relationship between income and complication risk. As there is now clear evidence that aggressive management of blood glucose, high blood pressure and high serum lipids will effectively prevent the micro- and macrovascular complications of diabetes (3-5;70;71), it follows that the earlier a specialist intervenes, the more effective these prevention strategies might be.

We must acknowledge that while these clinical differences may reflect differences in primary care or timing of referral, they may simply be the result of wealthier patients being more physically active and fit than their lower income counterparts. It has been shown in previous research that sedentary lifestyles are more common among lower income populations. Serum HDL is known to increase with exercise. Physical activity also decreases insulin resistance which, via multiple mechanisms, decreases triglyceride levels (72). The lower BMIs of the wealthier groups also support the possibility of a more physically active group.

This study has limitations. This is a cross sectional study that examined the clinical profiles of patients at one point in time. These referrals were not necessarily index referral, and had we compared clinical profiles at first contact with specialty care, it is possible that some of the clinical differences noted may have been attenuated. It is noteworthy that clinical data were entered into the DEC database from a standardized clinic referral form. All clinical data examined in this study, therefore, were provided by the referring physician. If doctors differ in the manner in which they complete, or do not complete this form, an information bias could be introduced to this study. We do not have any evidence, however, that physicians' documentation skills should differ based on the neighbourhood income of their patients, and would assert any information bias relating to income is unlikely.

Despite these limitations, this study provides important information in how the clinical profiles of patients with diabetes differ based on income. Given that elevated serum lipids, HBA1C and microalbumin to creatinine ratios are all significant predictors of atherosclerosis and mortality (43;44;46;73;74), it is quite plausible that these clinical difference mediate between income and health outcomes in this population. Whether these differences are influenced by patient, physician, or other factors, remains unclear. However, this study does provide reassurance that within Canada's single payer health care system, that these differing clinical profiles across income groups is not the result of differential prescribing practices. Overall, mediation use was higher in the lower income groups appropriately reflecting their higher burden of vascular risk factors.

CHAPTER 4- Association of Median Household Income with Burden of Coronary Artery Disease among Individuals with Diabetes (Thesis Sub-study 4)

4.1 Background

It is well established that socio-economic standing is associated with cardiovascular disease (CVD) risk. Numerous studies have demonstrated, in several developed countries, that the risk of CVD is inversely related to socio-economic status (32;33;75-77). Some have estimated that the population attributable risk associated with low income may be as high as 22% (78).

We have also shown that there is a socio-economic gradient with respect to the prevalence of diabetes (8;10;65). The higher prevalence of diabetes, and other cardiovascular risk factors such at serum lipid abnormalities (primarily low HDL and high triglycerides), smoking and obesity among low income populations is often cited as one of the reasons CVD is also more prevalent among these groups(8;13;14;59;79). However, several large population based studies have shown that low income is an independent risk factor for CVD (32;78;79).

It has been established that among patients with diabetes, low income patients appear to have more atherogenic clinical profile. At the time of presentation to specialty clinic, patients with low income are older, have a higher BMI and have lower serum HDL and higher triglycerides. It is not surprising then, that low income individuals with diabetes are also at the highest risk for developing cardiovascular- related complications and cardiovascular-related mortality. However, as with non-diabetic populations, the association between low-income and cardiovascular (CV) risk remains significant after controlling for differences in conventional cardiovascular risk factors (20).

There is an increasing appreciation that the increased CV risk seen in low income populations is mediated by processes beyond the traditional risk factors. Several studies have suggested that social and economic disadvantage serve as a significant chronic stress that leads to maladaptive neurohormonal responses. Chronic autonomic dysfunction and disturbances to the hypothalamic-pituitary-adrenal axis have both been implicated as mediators of coronary artery disease and it's complications among the economically disadvantaged (80;81). Others have suggested that low socio-economic standing may also be associated with a chronic inflammatory state as serum levels C-reactive protein, fibrinogen and homocysteine have all found to be inversely related to socio-economic status (41;42).

As evidence accumulates that relative social and economic deprivation have adverse physiologic effects and lead to poor CV outcomes, little is known about whether low income is associated with different degrees of atherosclerosis within the coronaries. The extent of coronary atherosclerotic disease has been shown to be a valid predictor of increased cardiovascular mortality (83;85). This study seeks to determine whether income is associated with the degree of coronary atherosclerosis and distribution of atherosclerosis among patients presenting for coronary catheterization.

4.2 Methods

Participants

Data on all patients with diabetes who had presented for cardiac catheterization in Alberta between January 2000 and December 2002 were examined in this study. In the cardiac registry used in this study, a patient is identified as having diabetes if, at the time of cardiac catheterization, the patient reports a history of diabetes that was either diagnosed or treated by a physician.

Data Sources

The Alberta Provincial Project of Outcome Assessment in Coronary Heart disease (APPROACH) is a prospective clinical data collection initiative including data on all adult patients undergoing cardiac catheterization in the province of Alberta (82). This data base includes patient demographic information, baseline clinical data, and information on the coronary anatomy and myocardial jeopardy.

Study Variables

Coronary anatomy is assessed at the time of coronary angiography by an interventional cardiologist and is recorded in a computerized data entry template (Heartview, Heart Ware, Durham, North Carolina, USA). From this template, the weighted Duke Index, Duke Severity and myocardial jeopardy scores can be calculated. The weighted Duke Index is a measure of the extent and severity of coronary artery disease. It measures the number of diseased major vessels, presence or absence of left main coronary disease, and percent narrowing of the major vessels (see Appendix A)(83) .

Severity of coronary disease was determined using the Duke Severity scale. Using Heartview, a patient is assigned a severity score ranging from 1 to 5 as follows: 1 = normal coronary arteries/ no coronary stenoses; 2= minor disease/ less than 50% diameter stenosis; 3= low risk disease/1 or 2 vessel disease with greater than 50% stenoses; 4= high risk group/ 2 vessel disease with proximal left anterior descending artery or 3 vessel disease; and 5= very high risk group/ left main disease (84).

Myocardial jeopardy is defined as the area of myocardium subtended by coronary arteries with clinically significant atherosclerosis. In other words, myocardial jeopardy refers to the amount of myocardium at significant risk for ischemia and ischemic injury. Three Jeopardy scores have been validated for use in APPROACH. These are the Duke Jeopardy Score, the Myocardial Jeopardy Index and the APPROACH Lesion Score (85). While each score is a valid predictor of cardiovascular mortality in and of itself, the scores do differ on how myocardial jeopardy is calculated. Due to these differing jeopardy calculations, it was felt prudent to examine the association of income with each jeopardy score.

Derivation of Income Quintiles

The postal codes of patients registered in the APPROACH were linked to their corresponding dissemination area using the Statistics Canada Postal Code Conversion File (PCCF). Neighborhood income data were obtained from Statistics Canada Census data (2001). We defined a neighborhood as equivalent to a census dissemination area (DA). Therefore, median household income per DA was the income measure used in this study. These data were merged with the APPROACH data on the variable DA.

Household income quintiles were generated from DA annual income data. The income quintiles, ranging from lowest to highest, were as follows: quintile 1 (<40577/ yr), quintile 2 ($40578-$48056/yr), quintile 3 ($48057-$55545/yr), quintile 4 ($55546-66548/yr), quintile 5 (>$66549/yr).

Statistical Analysis

Clinical characteristics are presented using proportions and descriptive statistics. Differences in dichotomous variables across income quintiles were analyzed using chi square analysis. Differences in continuous variables were examined using linear regression. Differences in ordinal scores across income quintiles were examined using analysis of variance.

To examine the association between continuous coronary anatomy variables and continuous myocardial jeopardy scores, linear regression modeling was employed. In these analyses, the lowest income quintile (quintile 1) was used as the reference. All other income groups were compared to reference group using dummy variables in the following regression equation:

$y = \beta_0 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x5$

Where y = dependent variable

B_0= the intercept

X_2= Inclusion in income quintile 2

X_3= Inclusion in income quintile 3

X_4= Inclusion in income quintile 4

X_5 = Inclusion in income quintile 5

β_i= the B-coefficient for the income quintile specific dummy variables.

Covariates considered in these analyses included age, sex, history of hypertension, dyslipidemia and smoking.

All statistical analyses were performed in STATA, version 8.

4.3 Results

5235 patients underwent cardiac catheterization during the study period. Among these eligible patients, 639 patients lived out of province or had incomplete address information so that linkage to income data could not be performed. After excluding these individuals, 4596 patients remained eligible for inclusion in the study. The clinical profiles of these patients are tabulated by income quintile in Table 4.1. Chi square analysis indicates that those in the highest income

Table 4.1: Baseline Characteristics

	Income Quintile					
	1 (low)	**2**	**3**	**4**	**5 (high)**	**p-value**
n	920	923	915	919	919	
Clinical Characteristics						
age	65.2	65.1	64.7	63.6	63.1	<0.00005
% Male	63.15	63.38	64.70	65.29	69.53	0.029
BMI (median)	31.2	38.6	31.5	32.2	30.7	0.2261
Hypertension (%)	74.9	75.6	73.4	71.3	71.3	0.107
Dyslipidemia (%)	64.5	67.6	69.8	70.0	68.2	0.076
Present Smoker(%)	25.2	20.26	21.4	21.9	19.7	0.039
Previous Smoker (%)	45.2	47.2	48.1	45.1	44.5	0.469
Renal Disease (%) **	10.1	9.4	7.3	6.4	7.8	0.24
On Dialysis (%)	4.6	5.6	4.6	4.5	4.7	0.760
Previous MI (%)	51.1	50.0	52.7	50.5	42.9	<0.0005
Cerebrovasc. Disease (%)	12.7	9.5	10.8	10.1	7.62	0.008
PVD (%)	13.7	11.8	13.9	12.7	10.2	0.108
Prior CABG (%)	6.0	6.5	5.5	4.8	6.4	0.491
Prior CHF (%)	28.8	24.2	21.3	20.8	20.8	<0.0005
Prior Lytic (%)	2.7	4.1	3.3	3.2	2.2	0.174
Prior PTCA (%)	4.46	6.4	5.7	6.0	5.6	0.458
Hx of Malignancy (%)	4.0	4.6	5.5	4.8	4.1	0.593
Hx of GI/ Liver disease (%)	6.4	7.2	4.8	7.0	5.6	0.1

**serum creatinine >200umol/L

quintiles were younger ($F=6.85$, $p<0.00005$), were more likely to be male ($X^2= 10.75$, $p=0.029$), were less likely to smoke and have a history of AMI ($X^2 = 21.08$, $p<0.0005$), congestive heart failure (CHF) ($X^2 = 24.57$, $p<0.0005$) or renal disease ($X^2= 11.23$, $p=0.024$). The wealthiest patients were less likely to be current smokers ($X^2= 10.1$, $p=0.039$), but otherwise were similar with respect to the prevalence of other risk factors such as hypertension or dyslipidemia.

There were no significant differences with respect to the history of prior revascularization across income quintiles. A total of 268 patients had undergone previous CABG, and 258 had received a previous percutaneous coronary intervention. To be prudent, these patients were excluded from the analysis examining the association between the income and the burden of cardiovascular disease, because these procedures can modify the apparent extent of coronary disease. One-way analysis of variance was used to determine if the burden of coronary disease differed across income quintiles. These results are shown in Table 4.2.

Table 4.2: Coronary Anatomy Scores

	Income Quintile					p-value
	1	2	3	4	5	
n	829	814	822	833	822	
Weighted Duke Index	7.38 (4.5)	7.42 (4.5)	6.67 (4.6	6.83 (4.5)	6.67 (4.6)	0.0002
Duke Severity	2.41 (1.4)	2.43 (1.4)	2.41 (1.5)	2.33 (1.2)	2.31 (1.5)	0.334
Jeopardy Scores						
Duke	46.23 (35.1)	41.03 (33.7)	39.04 (34.3)	39.33 (33.2)	36.44 (33.0)	0.0187
BARI	54.57 (35.4)	53.91 (35.1)	52.06 (35.7)	51.90 (35.1)	49.86 (35.8)	0.0604
APPROACH	45.36 (35.0)	44.37 (33.9)	42.60 (34.6)	43.29 (33.6)	39.96 (33.5)	0.0182
Lesion Counts						
Total lesions	2.70 (2.4)	2.61 (2.3)	2.51 (2.4)	2.61 (2.4)	2.43 (2.3)	0.1822
Lesions in LAD	2.47 (1.5)	2.50 (1.5)	2.49 (1.4)	2.47 (1.5)	2.37 (1.5)	0.3943
Lesions in Circumflex	2.20 (1.6)	2.26 (1.6)	2.13 (1.6)	2.17 (1.6)	2.05 (1.6)	0.1088
Lesions in RCA	2.37 (1.6)	2.38 (1.5)	2.32 (1.6)	2.43 (1.6)	2.43 (1.6)	0.7021

Means (sd) are tabulated

The highest income quintile had the least amount of coronary disease (as measured by the weighted Duke index) (F=5.51, p=0.0002) and the coronary artery disease among the wealthiest income quintile was graded as the least severe on the Duke severity scale, however, this latter finding was not statistically significant (F= 1.14, p= 0.334). The highest income quintiles had significantly less myocardial jeopardy as measured by the Duke (F=2.96, p=0.0187) and APPROACH Jeopardy Scores (F=2.98, p=0.0182). The wealthiest patients also trended toward lower BARI Jeopardy Scores, however, this did not reach significance (F=2.26, p=0.0604). Lesions counts did not differ significantly across income quintiles, but there was a trend towards the wealthiest patients having fewer lesions (F=1.56, p=0.1822) and fewer lesions in the circumflex artery (F=1.89, p= 0.1088)

On Heartview, other significant differences between income quintiles were noted (see Table 4.3). The wealthiest were the least likely to have clinically significant lesions (i.e. $\geq$ 70% stenosis) (B-coefficient -0.268 lesions, p=0.021) compared to the lowest income quintile. However, this difference was attenuated somewhat in a multivariate analysis that adjusted for differences in risk factor profiles (B-coefficient -0.215 lesions, p=0.056). The distribution of disease did not differ by income. In unadjusted analyses, patients in the highest income quintile were less likely to have disease in the circumflex artery compared to the lowest income group but this did not reach significance (B-coefficient = -0.134 lesions, p=0.072). This difference was further attenuated (B-coefficient = -0.104 lesions, p=0.143) after controlling for differences in age, sex, and cardiovascular risk profile. The different income groups seem to have similar degrees of coronary disease in the left anterior descending and right coronary arteries.

Table 4.3: Coronary Anatomy Regression

Anatomy Variable	Income Quintile	Unadjusted Coefficient (p-value)	Adjusted Coefficient (p-value)*
Total lesions (clinically significant)	1	Reference	Reference
	2	-.09 (0.438)	-.103 (0.358)
	3	-.185 (0.111)	-.196 (0.80)
	4	-.090 (0.438)	-.054 (0.629
	5	-.270 (0.021)	-.215 (0.056)
Lesions in LAD	1	Reference	Reference
	2	-.006 (0.928)	-.0124 (0.851)
	3	-.003 (0.960)	-.006 (0.931)
	4	-.010 (0.881)	.024 (0.711)
	5	-.097 (0.156)	-.058 (0.383)
Lesions in Circ.	1	Reference	Reference
	2	.035(0.629)	.029(0.679)
	3	-.094(0.203)	-.104(0.144)
	4	-.063(0.397)	-.037(0.606)
	5	-.134(0.072)	-.104 (0.143)
Lesions in RCA	1	Reference	Reference
	2	.033 (0.651)	.037 (0.595)
	3	-.076 (0.299)	-.076 (0.277)
	4	.026 (0.727)	.059 (0.398)
	5	-.036 (0.618)	.005 (0.943)

*adjusted for age, sex, hypertension, hypercholesterolemia and smoking history

The regression analysis examining potential differences in myocardial jeopardy across income quintiles is presented in Table 4.4. Patients in the highest income quintile had the lowest jeopardy scores. The wealthiest patients had significantly lower jeopardy scores as measured by the Duke, BARI and APPROACH Jeopardy scores. This difference remained significant after adjustment for differences in age, sex, and cardiovascular risk profile.

Table 4.4: Regression of Jeopardy Scores

Jeopardy Score	Income Quintile	Unadjusted Coefficient (p-value)	Adjusted Coefficient (p-value)*
Duke	1	Reference	Reference
	2	-.589 (0.725)	-.667 (0.676)
	3	-2.59 (0.12)	-2.70 (0.091)
	4	-2.29 (0.169)	-1.65 (0.301)
	5	-5.19 (0.002)	-4.22 (0.008)
BARI	1	Reference	Reference
	2	-.655 (0.704)	-.690 (0.556)
	3	-2.52 (0.149)	-2.59 (0.117)
	4	-2.68 (0.124)	-1.91 (0.247)
	5	-4.71 (0.007)	-3.53 (0.034)
APPROACH	1	Reference	Reference
	2	-.993 (0.556)	-1.01 (0.532)
	3	-2.76 (0.100)	-2.83 (0.078)
	4	-2.073 (0.216)	-1.40 (0.387)
	5	-5.40 (<0.0005)	-4.34 (0.007)

*adjusted for age, sex, hypertension, hypercholesterolemia and smoking history

4.4 Discussion

This study demonstrates that the wealthiest patients with diabetes have the lowest burden of coronary disease as measured by the weighted Duke Index and 3 validated myocardial jeopardy scores. As increasing Duke Index and jeopardy scores are associated with an increase risk of future cardiovascular mortality (85;86), this finding implies that the wealthiest patients in this study may have a survival advantage. Indeed, previous studies examining survival among the entire APPROACH cohort indeed demonstrates that the odds of mortality among the wealthiest patients is approximately half that of the poorest (OR=0.49, 95% CI=0.43-0.55) (52).

Cardiovascular disease is the leading cause of mortality among patients with diabetes and accounts for approximately 60% of deaths among adult patients with diabetes (5). Understanding what mediates the inverse relationship between socio-economic status and cardiovascular risk is highly important for those involved in diabetes care as diabetes is significantly more prevalent among low income populations. The reasons behind such gradients in CV risk and mortality are complex and likely reflect a combination of both social (health care access, utilization, health-related perception and behaviour) and biologic factors.

The results of this study would support that there is likely interplay between social and biologic factors leading to the finding of less coronary disease among the wealthy. Examination of the clinical profiles of these individuals at the time of catheterization shows us that the lower income groups were older and were more likely to have a history of previous vascular events such as a previous myocardial infarction or stroke. However, the use of revascularization strategies was similar across income quintiles. The fact that the previous revascularization rates do not mirror the event rate suggests that lower income patients either did not present in a timely manner so that revascularization (via thrombolysis or percutaneous translumenal angioplasty) could be performed, or may not have presented at all (unappreciated or silent presentations). This raises several questions as to whether health perceptions, health care seeking behaviour and health care access are the same across income groups. Do lower income patients experience ischemic symptoms in a similar manner as the wealthy? Were they able to access care as effectively as their wealth counterparts? When at the point of care, were they able to articulate their symptoms and concerns in a manner similar to the wealthy?

There is indeed evidence that among patients with coronary disease, the wealthy are likely more effective at accessing coronary procedures than the poor. Alter and colleagues demonstrated that even within a universal health care system, high socio-economic status is associated with a 23% increase in the use of acute percutaneous translumenal coronary angioplasty. Wealthy patients also receive treatment in a more expedient manner- high income was associated with a 43% reduction in wait-time for cardiac procedures (27). While previous research would indicate that in the individuals with diabetes access specialty diabetes care similarly across income groups, it is not known if this is true for other forms of specialized care, such as, cardiac services. However we do know that in comparison to those without diabetes, diabetic patients are less likely to receive revascularization or be followed by a cardiologist (87).

Health related behaviours have long been known to differ among the social classes. Less wealthy persons are more likely to have low fruit and vegetable consumption, are more likely to be sedentary, are more likely to be overweight, obese or have diabetes, and are more likely to smoke (8;13;14;59;88). It is cited that the socio-economic gradient in CVD risk is attributable to a similar socio-economic gradient in the prevalence of traditional cardiac risk factors (78;89;90). With the exception of smoking, we did not find that in this cohort of patients with diabetes, that there were significant differences in cardiac risk factors across income quintiles. This is in keeping with previous work that demonstrates an independent association between income and poor CV outcomes (32;78;79). And indeed, we demonstrate that high income is associated with significantly less coronary atherosclerosis even after controlling for prevalence of traditional cardiac risk factors. So it would appear that while there may be differences in health related behaviours, the differences in coronary disease cannot be attributed solely to such differences.

There is increasing evidence that there are several physiologic differences across income groups that may mediate the development of coronary atherosclerosis. Dysregulation of the hypothalamic-pituitary-adrenal axis, and particularly, loss of diurnal variation in serum cortisol levels is more common among lower socio-economic groups (36;39). This results in higher cortisol levels among these groups which can lead to a number of metabolic and inflammatory abnormalities that can leave affected individuals more vulnerable to the development of atherosclerosis. Individuals of lower social standing have also been found to be more vulnerable to ischemia related arrhythmias. Low income patients have been found to have higher resting heart rates and lower heart rate variability leading researcher to suggest that low income patients may be experiencing autonomic dysfunction relative to their wealthier counterparts (80;81).

The present study is limited in that it is a cross-sectional examination of the association between income and coronary disease. A longitudinal study examining exposure to various levels of income with serial coronary angiography would have enriched our understanding of how these two variables are related. In this cohort of individuals with diabetes, we also could not account for level of glycemic control in our multivariate models. Given the established link between hemoglobin A1C and CV risk, this is a limitation (3-5;73). While our previous study would indicate that HBA1C may not differ markedly across income quintiles, we cannot be certain that the differences in coronary disease across income groups in this population were not influenced by difference in glycemic control. Similarly, cardioprotective medication use across income quintiles is not known. It is possible that the differences seen in coronary atherosclerosis across groups really reflect differences in ability to access proven cardioprotective therapies.

In conclusion, this study adds to our existing knowledge by demonstrating that wealthy patients have less coronary atherosclerosis. The lighter burden of coronary atherosclerosis may indeed be one of the mediating factors explaining the lower CV mortality among wealthy patients. This finding highlights the importance of low income as a risk factor of coronary artery disease and the need to look further into the precise mechanisms that underlie this finding of significant cardioprotection associated with advanced economic standing.

Chapter 5: Discussion

5.1 Restatement of Objectives

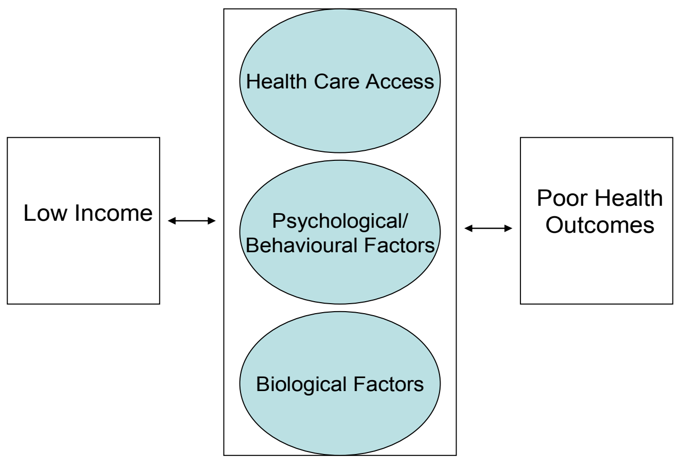
There is an extensive body of research that examines the relationship between low socio-economic status and health. In studying a variety of populations, it has been proposed that inequities in health care access (26-28;91;92), differences in psychological, behavioural and personality traits (20;33;66;80;93), and differences in biologic and physiologic factors are mechanisms mediating this relationship (42;81).

While we are beginning to know more and more about the various factors involved in the income/health association in general, little is known about this link among those with diabetes. Diabetes is recognized to be more prevalent among those living in the lower economic strata of society (8;10;65). Within this population of individuals with diabetes, poor health outcomes are most likely to occur in the most economically disadvantaged (19;20;53). This thesis sought to characterize some of the factors mediating between income and outcome. By identifying such mediators, targeted interventions can then occur in an attempt to reduce the risk of poor health outcomes among the economically and socially disadvantaged.

5.4 Returning to the Conceptual Model

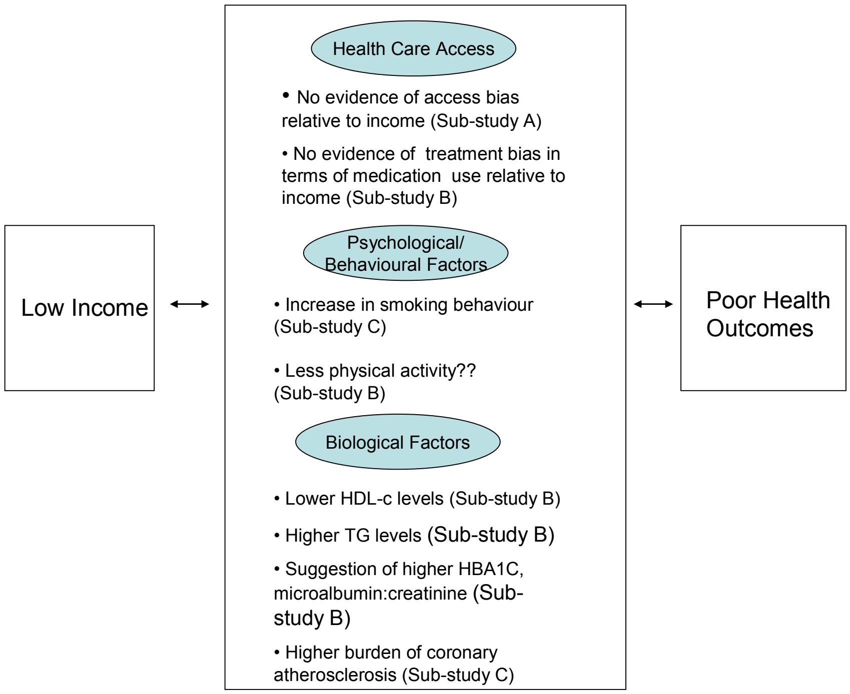
In the introduction, a conceptual model was proposed regarding the association between low income and poor health outcomes and what factors may be at work to mediate this relationship. This model appeared as follows:

Figure 5.1- Conceptual Model for Thesis



In this thesis, 3 studies were performed to confirm the association between income and health in patients with diabetes, and to describe whether differences existed across income quintile with respect to access to health care, clinical profiles, risk factor burden, and burden of coronary atherosclerosis. In doing so, this thesis has informed the conceptual model and has provided insights into the potential mechanisms that intervene income and health. At the conclusion of this thesis we can now expand the conceptual model:

Figure 5.2- Expanded Conceptual Model following completion of Thesis



In sub-study A it was demonstrated that there is higher prevalence of diabetes among the lowest income quintiles, and that referral for specialty diabetes care was similar across income quintiles after controlling for these differences in diabetes prevalence. This would indicate that access to diabetes care is not related to income. Sub-study B revealed that there are significant clinical differences among the patients referred for diabetes care across income quintiles. The least wealthy patients were older and had significantly higher BMIs than the wealthy patients. There was a higher burden of vascular risk factors noted in the lowest income groups including higher triglyceride levels, lower HDL-c levels and a trend towards higher microalbumin to creatinine ratios. Medication use was similar across income groups, and in some instances, highest in the lowest income groups. Sub-study C demonstrated that in a cohort of diabetes patients undergoing cardiac catheterization, the wealthiest patients had the least amount of coronary atherosclerosis. A socio-economic gradient in smoking was also found with the highest rates of active smoking in the lowest income groups.

5.3 Low Income- Confounder or True Determinant of Health?

A recent study by Alter demonstrated that in a cohort of Canadian patients, that high SES was highly protective in terms of cardiovascular mortality following acute myocardial infarction as evidenced by a hazard ratio (at 2 years) of 0.45 (95% CI 0.35-0.57). After controlling for traditional cardiovascular risk factors, however, this apparent protection was attenuated greatly (HR= 0.77, 95% CI 0.54-1.10) (90). This raises the question whether indeed SES, or income status, is a determinant of health, or simply a confounder. In an attempt to address this question, Yusuf and colleagues performed the INTERHEART study (89). This study was a very large, international study that identified acute myocardial infarction (AMI) cases and controls within 52 countries of varying economic status. The INTERHEART investigators concluded that 90.4% of AMIs could be attributed to the “traditional cardiac risk factors”. This study would also suggest that income may in fact be a confounder, rather than an independent risk factor contributing to the development of cardiovascular disease. Only a small proportion of AMI is attributable to something beyond the traditional risk factors, and there are a number of other non-traditional risk factors that may be at work as well.

However, it is important to note that one of the 9 risk factors considered in the INTERHEART model was “psychosocial factors” which was a composite of scores on self-reported depression, stress (personal, professional and financial) and self-mastery. The overall population attributable risk associated with this variable “psychosocial factors” was 32.5% (95% CI 25.1%-40.8%). This variable is very much tied to socio-economic status. In truth, this study therefore reveals that economic disadvantage is not a confounder, but a factor that may contribute significantly to the development of heart disease. This finding is in keeping with the landmark Whitehall study that demonstrated that the risk of cardiovascular mortality was 3 fold higher among the lowest social class. After controlling for other vascular risk factors, the risk of cardiovascular mortality remained 2 fold higher among the most socially disadvantaged (79). Together, these two studies provide compelling evidence that income and social standing are determinants of health.

5.4 Social vs. Biologic Factors

Globally, this thesis research suggests that biologic factors may be a more dominant force in terms of contribution to the income/health relationship. There appears to equitable access to diabetes care and apparently equitable use of medications. However, in spite of these findings, lower income patients had a higher burden of vascular risk factors and the wealthy had the least amount of atherosclerosis. These latter two finding raise questions about whether there may be physiologic differences between the rich and poor, although to attribute these findings purely to biology would likely be simplistic and inaccurate.

It is important to realize that these studies also inform of possible subtle differences in process of care and behaviour across income quintiles. Lower income patients present to diabetes clinic, and to cardiac catheterization at an older age. They are on more medications to prevent events but they present to cardiac catheterizaton with a history of more vascular events. It would appear that lower income patients may be presenting later in the course of their diabetes and heart disease. Whether such a difference is related to physician (differing thresholds for referral or investigation) or patient factors (differences in ability to report symptoms, differences in the experience of symptoms) could not be addressed in this thesis.

There was also some indication in this thesis research that the wealthy patients may be more physically active and fit. The wealthy are leaner, have a trend toward better glycemic control but are on fewer medication and have higher HDL-c levels. There is clear evidence that exercise is an effective way to lower HBA1C and improve levels of HDL-c (72).

So while these sub-studies document significant biologic differences among social groups, they also inform us of potential behavioural differences and raise hypotheses about process of care differences. In the end, there is likely a complex interplay between all of the proposed mediators in the income/health relationship.

5.5 Limitations

The relationship between health and economic status is complex. There are certainly numerous links that could not be completely explored with a single thesis. Other investigators have documented differences in psychological measures such as perceived level of control and self-mastery across income groups and have linked these to differences in health outcomes (32). Personality traits, particularly measures of aggression, differ across economic strata and have been implicated in cardiovascular health outcomes (34;35;94). Neither psychological nor personality traits were examined in this thesis. There are also likely differences in health-related behaviours that were suggested but not thoroughly examined in this thesis. Sub-study B suggests that the wealthy may be more physically active and indeed, there is evidence from non-diabetic population that this may be the case. There is also clear evidence from national health survey data that the wealthy are more likely to have diets higher in fruits and vegetables and lower in calorie dense, processed food (13;14;88). Sub-study C indicates that the least wealthy are more likely to be active smokers and indeed, this is congruent with previous population based research (13;14;66;88). While differences in smoking were considered in the analyses in sub-study C, differences in physical activity and diet were not documented or controlled for in any of the analyses.

As mentioned previously, socio-economic status is a complex structure, and this thesis examined only one component- income. The SES construct involves not only income, but housing status, relative deprivation measures plus educational and occupational experiences. The mediators of the relationship between SES and health may have been more completely characterized had these other measures been considered.

It is also important to reiterate that an area level income measure was used in these sub-studies. In the reporting of these investigations, reference was made to "wealthy" patients and "less" affluent patients, but these designations were based on neighbourhood and not personal wealth. While indeed area level income measures have been used extensively and have been validated as an independent SES construct (38;51;52), this remains an ecologic measure. Some caution always need be taken when trying to relate data derived from aggregate groups of people to individual persons. Nevertheless, despite inconsistent assessments of neighbourhood income as a proxy measure for individual income, studies have unanimously indicated that neighbourhood income is a prognostically important measure, even when it is not concordant with individual income (49-51).

The limitations of each data set used in this thesis must also be considered. The Diabetes Education Centre (DEC) database is a clinical data base whose sampling frame is the city of Calgary, Alberta. For a person to be registered in the database, they must have received a referral to the DEC from their physician *and* attended at least one clinic appointment. This data set, therefore, is not representative of patients who do not have ready access to a physician nor those who cannot (or would not) attend clinic. The clinical information in the data set is collected from standardized referral forms. There is no obligation for a referring physician to provide this information to ensure referral. As a result, complete clinical data is not always provided. There is also no way to ensure the accuracy of the information provided, without embarking on a formal validity study with direct contact of patients. As mentioned in Chapter 3, there is no reason to think that these errors in reporting should differ across income quintiles, but, these general limitations of the data set should be acknowledged.

In this thesis, “medication use” was examined across income quintiles. Medication use was defined as medication prescribed (as reported on the standardized referral form) at the time of referral to the DEC. This data set did not contain information on duration of medication use or adherence to prescribed medications. Both of these factors impact drug efficacy, and therefore effect health outcomes.

All clinical data within the APPROACH data base are based on chart review at time of cardiac catheterization. Twice yearly linkages with administrative data ensure that the diagnoses captured in APPROACH are accurate.

Data on coronary anatomy and myocardial jeopardy are calculated from the electronic template, Heartview. Heartview is generated by the interventional cardiologist performing the cardiac catheterization and coronary angiogram. The inter-rater reliability of these cardiologists is not known.

5.6 Direction & Nature of Income/Health Relationship

It has been implied in this thesis that a certain income status leads to specific health outcomes, but it is not known whether indeed this is a causal relationship. The studies performed in this thesis were all cross-sectional in nature. Such studies inform us of associations between given variables at one point in time only. This study design is not able to examine the longitudinal effect of various income levels on health outcomes, nor can this design account for changes in other clinical factors (lipid levels, HBA1C, duration of therapy) over time that may also be associated both with income and health outcomes.

Despite some consistency in study findings, the findings of these three sub-studies are certainly not enough to suggest causation. In 1965, Sir Bradford-Hill outlined his now famous criteria for inferring causation from epidemiologic studies (95). These criteria include: consistency, biologic plausibility, strength of association, dose-responsiveness, specificity, temporality and analogy. To infer causation, there most be a large and compelling body of evidence that demonstrates that most, if not all, of these criteria are met (96). This thesis demonstrated a consistent finding of a higher burden of cardiovascular risk factors and cardiovascular disease among the lowest income groups. A dose-response was also noted in the burden of risk factors, the lowest income groups having the most atherogenic clinical profiles, and the wealthiest, the least. This thesis, in examining biologic mediators of the income/ health outcome relationship speaks directly to biologic plausibility. However, these studies did not address specificity. As mentioned, only one aspect of the larger SES construct was examined. And these cross-sectional studies certainly could not speak to temporality of the relationship. The direction of the income/health outcome relationship also remains uncertain.

It is plausible, for example, that the direction of the relationship relates to the fact that ill health compromises the ability for one to achieve in the educational or occupational setting. Chronic or frequent illness may impact on school attendance and performance. Frequent absenteeism from the workplace due to illness may result in the loss of employment. Illness may result in disability which could lead to early retirement from the workforce. All of these factors may contribute to the finding of a higher burden of illness among lower income groups- but in this formulation of the income-health relationship, the direction of causation involves illness limiting economic and occupational opportunity, and thus causing poverty. This ‘reverse causation’ argument for the income-health relationship can not be overlooked as a potential contributor to the strong associations that are demonstrated both in the literature and in this thesis.

5.7 Potential Contributions

This thesis adds to the existing body of knowledge by better characterizing some of the mediators of poor health outcomes among patients with diabetes. Davey-

Smith and colleagues demonstrated in the MR.FIT study that for men, low income was a significant predictor of cardiovascular mortality on an order of magnitude that was similar to hypertension, smoking and high serum cholesterol (97). This thesis re-iterates the importance of low income in predicting poor outcomes. It asserts that there are clear clinical differences relative to income and it is important for health care providers to recognize the increased risk that is associated with low income and to be aggressive at treating recognized risk factors like hyperglycemia and hyperlipidemia among low income groups (3-5;71).

5.8 Moving Beyond Description

Ideally, this thesis should provide insights that lead to interventions focused on improving outcomes among individuals with low income. Given the complexity of the income/health link, and the number of potential mediators, there are numerous interventions that could be considered. Interventions could be in the form of clinical initiatives directed at the mediating factors or alternatively could take the form of large scale social policy or programs to address the underlying problem of societal poverty.

Examples of clinical interventions or initiatives directed at the mediators of the income/ health outcome relationship could be:

Biological Interventions

- An evaluation of the efficacy of clinical practice guidelines that promote risk stratification on patient income. This might assist in low income patients being screened more frequently with the result of evidence therapies being employed in a more timely fashion.

Behavioural Interventions:

- Anti-smoking initiatives aimed specifically at low income populations- this might include an evaluation of the efficacy of providing smoking cessation medications free to low income patients.
- Evaluation of various healthy living initiatives aimed at low income populations.

Health Care Access

- Studies need to be done to examine whether income and education level are associated with differences in presentation of an acute ischemic event. This would involve an examination into potential differences in both the symptoms of an acute event and the timing of presentation to acute care following an event.

If indeed it is the low income status that leads to poor health incomes, we could potentially target the problem at a societal level by developing social policies that attempt to reduce the disparity in wealth. Social programs that increase income, either directly via a monetary allowance, or indirectly through changes in taxation or subsidization, are thought to be the most effective way to narrow economic disparities. There have been numerous studies that evaluate social programs that increase income among the poorest members of society. Connor and Adams have both performed systematic reviews trying to determine the direct benefits on health related to such social programs (98;99). Unfortunately, despite numerous studies on these programs, the impact on health was rarely considered. Both Connors and Adams found that the endpoints of interest related to workforce participation. The studies that did examine health-related endpoints generally looked at health care utilization. In most instances, people in the income benefit groups were found to use acute care resources less than those in the control groups. The Seattle/ Denver Income Maintenance Experiment found that among the group receiving extra income, men had few days in hospital and women had shorter duration of illness compared to the men and women in the control groups (99). A small Canadian study by Lafave gave a supplementary allowance to mentally ill patients living in poverty (100). This study found a trend towards decreased hospitalizations and improved quality of life but was under-powered to show significant benefits.

Thomson reported a very interesting challenge that faces researchers interested in evaluating the efficacy of social programs to improve outcomes in the poor. While some randomized and quasi-experimental studies on income supplementation have been done, hard health outcomes have note been assessed. Therefore, more study is required in this area to support policy change in this regard. However, given the body of evidence that low income is such a striking risk factor for poor outcome, withholding income from a control group in an evaluative study would pose significant ethical challenges (101).

5.9 Conclusions

This thesis research: 1) confirms that low income is associated with higher diabetes prevalence; 2) illustrates that among those with diabetes, income level is associated with a higher burden of vascular risk factors; and 3) that income level is associated with burden of coronary disease. This research has therefore shed some light on the mediators of the income/ health outcome association.

More work is now needed to both 1) expand our understanding of the mediators *and their inter-relationship, and also 2)* to move beyond description toward interventions that can address this challenge. Given the many factors involved in the income/ health outcome association, such interventions can be clinical and be health care provider directed. Alternatively, interventions could be social, and guided by policy change. Rigorous evaluation of the efficacy of either intervention is of utmost importance and consideration to the use of hard, clinically relevant endpoints would greatly advance this area of research.

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Appendix A

Weighted Duke Index

Extent of CAD
1- Disease less than 50%
2- VD (50 to 75%)
3 - VD (95%)
4 - Vessel Disease
5- VD (both 95%)
6 - VD (95% prox. LAD)
7 - VD (95% LAD)
8 - VD (95% prox. LAD)
9 - Vessel Disease
10 - VD (one 95%)
11 - VD (prox. LAD)
12 - VD (95% prox. LAD)
13- Left main disease
14 -Severe Left main disease