Geographic and Socioeconomic Determinants of Health Services Utilization and Clinical Outcomes in Ischemic Heart Disease Patients in Nova Scotia

by

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Table of Contents

List of Figures

List of Tables

Abstract

The province of Nova Scotia has among the highest prevalence rates of ischemic heart disease (IHD) in Canada. Despite the considerable resources invested in the treatment of IHD in Nova Scotia, very little is known regarding access to cardiac care and outcomes among patients with IHD in this province. The purpose of this thesis is to gain insight into the complex relationships underlying sex, socioeconomic status (SES), geography and cardiovascular care in Nova Scotia through the use of rich observational and administrative data and traditional as well as non-traditional statistical methodologies.

In patients undergoing coronary artery bypass grafting (CABG), women had worse long-term rates of mortality and/or readmission when compared to men following adjustment for baseline differences in co-morbid disease and clinical presentation. In patients admitted to hospital with an acute myocardial infarction (MI) in Nova Scotia, place of residence in areas remote from the single tertiary cardiac care centre in Nova Scotia emerged as an independent predictor of lower rates of cardiac catheterization within the first six months following admission as well as higher long-term rates of readmission to hospital for any cardiac cause. SES, as defined by income and education level, did not emerge as an independent predictor. This theme re-emerged when the association between SES, geography and intermediate-term outcomes was explored in patients undergoing CABG. Following adjustment for differences between patients, place of residence was found to be an independent predictor of higher rates of readmission to hospital for any cardiac cause over time following CABG. Finally, with the support of hierarchical logistic regression modeling and detailed individual- and area-level data, it was found that lower individual-level income in addition to place of residence emerged as independent predictors of increased cardiac readmission.

The negative effect of female sex, SES and geography on access to cardiac care and cardiovascular outcomes in Nova Scotia has been clearly demonstrated in this thesis. . Further research into the causal mechanisms underlying these inequities is required in order to determine the causal mechanisms underlying these inequities. This will allow for the development of interventions designed specifically at minimizing these disparities.

Acknowledgments

When I first started my residency in cardiac surgery in 1998, I had doubts concerning my commitment to becoming a clinician scientist. The prospect of having to spend a year dedicated towards academic enrichment with little in the way of any clinical distraction was somewhat foreboding. However, much to my surprise, my time "on research" was a time when my inclinations changed rather dramatically. It was a time during which I was able to explore new opportunities, forge exciting and enduring relationships and gain perspective in life, a perspective that is often lacking during a residency in cardiac surgery. This thesis is a manifestation of these experiences.

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List of Abbreviations Used

ACE	Angiotensin converting enzyme
ARB	Angiotensin-II receptor blocker
BMI	Body mass index
CABG	Coronary artery bypass grafting
CCS	Canadian classification system (angina)
CHF	Congestive heart failure
CI	Confidence interval
CIHI	Canadian Institute for Health Information
COPD	Chronic obstructive pulmonary disease
Cr	Creatinine
CVD	Cardiovascular disease
DHA	District health authority
EF	Ejection fraction
HMG	3-hydroxy-3-methylglutaryl
HR	Hazard ratio
ICD-9-CM	International classification diseases, 9th clinical modification
ICONS	Improving Cardiovascular Outcomes in Nova Scotia database
IHD	Ischemic heart disease
LIMA	Left internal mammary artery
LM	Left-main disease
MA	Metropolitan area

MHC	Maritime Heart Centre database
MHCCSR	Maritime Heart Centre Cardiac Surgery Registry
MI	Myocardial infarction
NYHA	New York Heart Association (functional classification)
OR	Odds ratio
PCI	Percutaneous coronary intervention
QE II	Queen Elizabeth II
RA	Rural area
SES	Socioeconomic status
UA	Non-metropolitan urban area

Chapter 1: Introduction

1.1 Introduction

At the individual level, disease is traditionally thought of as arising from molecular, genetic and/or physiological processes are impaired and that have resulted in a localized or systemic response that runs counter to the normal functioning of the human body. As a consequence of this biological framework, attempts to mitigate the negative effects of disease have specifically targeted these underlying mechanisms. Over the past few decades, the roles played by sociodemographic and environmental factors in affecting disease at both the individual and population level have garnered increasing attention. Numerous studies have consistently demonstrated the inverse relationship between socioeconomic status (SES) and adverse health outcomes(1), regardless of which marker for SES is used(2). The resulting shift from an almost exclusively biological model to one where both sociodemographic and environmental factors are thought to act alongside or in combination with biological factors has significantly changed the way disease is perceived and how policy makers and health care providers formulate interventions geared at reducing the burden of disease.

The purpose of this chapter is to provide an overview of the landmark studies that have served to initiate much of the discussion that exists today around the role of socioeconomic status and geography in determining cardiovascular health at both the individual and population levels. This background will provide the context for the experimental results concerning the effect of sex, geography and SES on health care service utilization and clinical outcomes in patients with cardiovascular disease in Nova Scotia, Canada.

1.2 Socioeconomic Status, Geography and Cardiovascular Health

Prior to the mid-1970's, very little was known about the relationship between SES and cardiovascular health. Early studies that attempted to determine the impact of SES employed a very elementary approach to its measurement, often characterizing individuals as being either above or below the poverty line(3). This threshold model of poverty, while valuable in bringing attention to the role of SES in health outcomes analyses, did not allow for a more nuanced examination of the effect of socioeconomic gradient on health outcomes. .

The Whitehall studies were among the first to challenge the threshold model(4-9). The original Whitehall study assessed the relationship between grade of employment, prevalence of coronary risk factors and rates of ischemic heart disease-related mortality in 17,530 male British civil servants between the ages of 40 and 64(4, 5). Men in the lowest employment grade, when compared to those in the highest employment grade, had higher prevalence rates of angina and ischemic-type electrocardiographic abnormalities. At a follow-up of seven and a half years, ischemic heart disease (IHD)-related mortality was 3.6 times higher in the lowest employment grade as compared to the highest employment grade, a difference that persisted after adjusting for the higher rates of IHD-related risk factors in the lowest employment grade. This mortality differential extended to non-cardiac and all-cause mortality with evidence of a stepwise relation between employment grade and mortality(6). A follow-up study of the original cohort at 25 years established that the mortality gradient persisted over the long-term(7, 8). The Whitehall

II study was designed to investigate the degree and causes of the social gradient in morbidity in a new cohort of individuals(9). From 1985 to1988, Marmot *et al.* surveyed 10,314 male and female British civil servants between the ages of 35 and 55. They found that in the 20 years that had elapsed since the original Whitehall study, social differences in the prevalence of angina and ischemic-type electrocardiographic abnormalities had not diminished and that employment grade differences in health-risk behaviours (smoking, diet and exercise), economic circumstances, work-related circumstances (job satisfaction) and social supports also persisted.

At the same time that the Whitehall studies were being conducted in the United Kingdom, studies were being carried out in the United States to determine the association between socioeconomic factors and cardiovascular disease risk factor development and related outcomes. The Evans County Georgia Heart Study, conceived by Hames *et al.* and begun in 1960 in a legally segregated, biracial, rural community, found that the prevalence of coronary heart disease was lower in black men than white men and that this prevalence varied directly with social class(10). Similarly, mean cholesterol levels were lower in blacks than whites and increased from black to low social class white to high social class white participants, although the difference between low social class and high social class whites disappeared by 1967(11). In contrast to serum cholesterol levels, mean systolic and diastolic blood pressures were markedly higher in black men and women and varied inversely with social status among white men and women. The Charleston Heart Study, set in the bi-racial community of Charleston County, South Carolina in the early 1960's, served to build on the work of the Evans County Study(12, 13). It found that blood pressure was higher among black men and that, more specifically, there existed a direct relation between blood pressure and skin tone, i.e. the darker the skin tone, the higher the blood pressure. However, upon closer examination, it became evident that skin colour was a surrogate for social status and that the true relationship existed between blood pressure and social status. In two separate follow-up studies of the initial Charleston Heart Study cohort, one at 14 years and the other at 28 years, Keil *et al.* found that rates of acute myocardial infarction (MI) and IHD among black men of high SES were half those of black men of lower SES(14) and that age-adjusted rates of IHD-related mortality were higher among individuals of lower SES irrespective of skin colour(15).

In the current era, much evidence points to the ongoing adverse effect that lower SES has on cardiovascular health(16-20). In the Atherosclerosis Risk in Communities Study, Diez Roux *et al.* examined 15 800 persons aged 45 to 64 years from four separate communities between 1987 and 1989 and looked at the association between SES and level of preclinical atherosclerosis, as quantified by carotid artery intima-media wall thickness(16). They found that mean carotid wall thickness varied inversely with each of the measures of income, education and occupation for white and black men and women. Furthermore, they found that rates of cardiovascular risk factors also differed significantly by income and education in all race/sex groups. Haywood *et al.* assessed the potential impact of SES on health-care seeking behavior among patients presenting with suspected acute coronary artery disease symptoms between 1988 and 1990(17). They found that low SES subjects were more likely to describe themselves as being in fair to poor general health and to have worse cardiac risk profiles than middle SES subjects. Tofler *et al.*, as part of the Multicentre Investigation of the Limitation of Infarct Size study, compared the course of 363 patients with acute MI who did not complete high school with that of 453 patients who did complete high school and found that adjusted four-year mortality rates were significantly higher in the less educated group(18). Barakat *et al.* looked at the influence of socioeconomic deprivation on case fatality following acute MI(19). A total of 1417 white and South Asian patients were admitted to hospital with acute MI in east London, United Kingdom between January 1988 and December 1996 and formed the final study population. Patients from more deprived enumeration districts had a higher risk of recurrent ischemic events (death, recurrent MI, or unstable angina) over the first 30 days. Philbin *et al.* investigated the relationship between income as a measure of SES and the frequency of hospital readmission for heart failure(20). A total of 41 776 African American or Caucasian hospital survivors with a principal discharge diagnosis of heart failure between January 1995 and December 1995 in New York State were identified using administrative data. In a fully-adjusted, multivariate model, income remained a significant, independent predictor of increased rates of readmission, with an increase in the risk of readmission noted in association with lower income levels. Boscarino *et al.* examined the effect of community SES and race on survival following coronary artery bypass grafting (CABG) in Louisville, Kentucky in 1994 and found that patients from counties with the lowest housing values had a significantly increased risk of mortality 36 months after CABG(21). Similarly, Ancona *et al.* assessed the effect of SES on access to and 30-day mortality following CABG in Rome, Italy from 1996 to 1997 and found that individuals from the most socially disadvantaged SES stratum experienced the lowest rates of CABG and the highest 30-day mortality rates(22).

Of interest is the degree to which the inverse relationship between SES and cardiovascular health has increased over time. Singh and Siahpush examined all-cause and cardiovascular mortality in all United States counties in men and women aged 25 – 64 years between 1969 and 1998 and found that socioeconomic gradients in both all-cause and cardiovascular mortality had grown substantially during that time(23). Similarly, Gonzalez *et al.* conducted a systematic review of cohort and case-control studies that looked at the relationship between SES and IHD and were published between 1960 and 1993(24). In these studies, SES was measured either using education level or occupation. They found that the odds ratio for IHD in manual workers rose progressively over the study period.

1.3 Causal Pathways

The causal pathways underlying the association between socioeconomic deprivation, place of residence and adverse health outcomes are the subject of much speculation and study. In attempting to understand these mechanisms, great effort has been put into better defining SES and geography. First of all, SES and geography are frequently employed as "snapshot" variables, characteristics defined at a particular point in time that are applied to the individual in question. The limitation of such an assignment lies in its inability to distinguish, for example, between someone who has lived their entire lives in a state of socioeconomic affluence and someone who has managed to emerge from a state of poverty only recently to join upper-class society. By assuming that both individuals are equivalent because they currently share the same socioeconomic designation, one risks overlooking the potential role that early deprivation in life might have in determining long-term health. A growing body of literature focused on the study of cumulative life-course socioeconomic position has determined that it is overly simplistic to make such an assumption and that a comprehensive assessment of both early life events and environments as well as later life experiences and health risk factors is necessary in order to truly understand the association between SES, geography and health(25-28). Secondly, SES and geography have traditionally been variables assigned to the individual without taking into account the possible interplay that may exist between an individual's socioeconomic status and their relative position within a societal, political, environmental or even cultural context. McMichael lamented this growing preoccupation with individual-level risk factors and felt the need for emphasis to be placed on population-level influences as well as individual-level risk factors(29). In recent years, researchers have increasingly utilized data at both the individual and contextual level to predict health behaviours and outcomes with the support of hierarchical logistic regression modeling techniques(30-35), thus, in turn, providing a greater understanding of how SES and geography function as determinants of health.

Despite the many efforts to better define SES and geography, the role that these variables play in determining health and health-related outcomes remains speculative. Many have proposed that SES has an indirect effect on health by promoting adverse health risk behaviours and lifestyles, exposing individuals or groups of persons to environments that may not be conducive to good health (e.g. poor housing, pollution, crime), impeding access to care or social support networks, creating stressful situations and provoking feelings of insecurity about one's position, and inhibiting one's ability to control his or her environment(36-40). The remainder of this section will focus on access to care and its effect on the SES, geography and adverse cardiovascular health outcome relationship.

Access to care has been defined as "the opportunity or right to receive health care"(41) and "the timely use of personal health services to achieve the best possible outcomes"(42). Such timely access to care for patients with cardiovascular disease, in particular those with symptomatic IHD manifesting as either unstable angina or an acute MI, has been shown in randomized controlled trials to reduce morbidity and mortality(43-45). However, numerous studies have demonstrated significant variability in both rates of and wait times for invasive cardiac procedures in patients with IHD. Pilote *et al.* found substantial regional variation in the management of acute MI across the United States in terms of cardiac drug prescription and utilization rates and cardiac procedure rates(46). Numerous studies have attributed such variation in the United States to racial inequalities(47-52), while others have implicated differences in education(53), household income(54) and geographic proximity to revascularization facilities(55) as being responsible for such discrepancies. Studies performed outside of the United States have similarly demonstrated variations in rates of and wait times for invasive coronary procedures by SES and geography(56-58). Manson-Siddle and Robinson examined the impact that allocation of additional resources toward increasing overall cardiac catheterization and coronary revascularization rates had on socioeconomic inequities in cardiac procedure utilization and found that such resource allocation, despite not being targeted specifically at deprived or disadvantaged groups, did serve to reduce socioeconomic inequities in rates of cardiac catheterization(59). However, not everyone has been convinced that differential access to care is responsible for social and ethnic differences in IHD outcomes. Britton *et al.*, as part of a follow-up study to the original, population-based Whitehall II study, showed that although there existed significant social gradients in IHD-related morbidity and mortality among civil servants in London, England, there was no association between social position, ethnicity and the use of cardiac procedures or secondary prevention drugs, leading them to conclude that factors other than access to care were responsible for the social and ethnic differences in IHD(60).

1.4 A Canadian Perspective

Where identified, impaired or diminished access to care has more often been thought to reflect a failure on the part of a health care system rather than a failure on the part of the individual. The negative association between SES, geography and access to care is therefore attributed to the notion that people of lower SES or of a particular place of residence receive less prompt health care than people of a higher SES or of a more favourable place of residence and that this discrepancy is system-driven and not patient-driven. In countries such as the United States where multiple tiers of health care delivery exist and level of care depends largely on an individual's level of insurance coverage, one would intuitively assume that a multi-tiered health care system would encourage a socioeconomic and geographic gradient. On the other hand, one would surmise that in a system with universal health coverage system, as pertains in Canada, where all individuals regardless of age, sex, race, socioeconomic status or place of residence are assured reasonable access to quality health care(61), such a gradient would either not exist or be severely diminished. This has been shown not to be the case.

Many of the initial studies examining utilization rates of cardiac procedures and how they were affected by SES and geography were performed in the province of Ontario. The following is a brief overview of these studies, which helped to expose the inequities that existed in the Canadian health care system. Jaglal and Goel examined the social class distribution of risk factors for IHD and the incidence of IHD and discovered that having an elevated cholesterol level, high blood pressure, diabetes, being overweight or smoking was more prevalent among those with low SES and that the 10-year probability of IHD was about twice as high among persons with lower SES(62). At about the same time, Naylor and Jaglal revealed significant regional variations in use and time of coronary revascularization following an acute MI(63), while Cox *et al.* showed that patients were more likely to have had revascularization when they had been admitted to a teaching hospital(64). Yet, it was the landmark paper by Alter *et al.* which first brought international attention to the effects of SES on access to invasive cardiac procedures and on mortality following an acute MI within a Canadian setting(65). Specifically, they showed that increases in neighbourhood income were associated with an increase in rates of cardiac catheterization and with a decrease in wait times. Furthermore, they demonstrated a significant inverse relationship between neighbourhood income and mortality at one year. In subsequent studies by the same group, patients admitted to hospitals with invasive facilities were much more likely to undergo revascularization and experienced significantly lower 5-year rates of recurrent cardiac hospitalization and emergency department visits, even after adjustment for differences in sociodemographic and clinical factors and procedure utilization(66). Socioeconomic gradient in cardiac catheterization use following acute MI was also found not to be driven by geography and the effect of SES was determined to be as important in tertiary hospitals as it was in community institutions(67). However, more recently, Alter et al showed that the inverse relationship between income and two-year mortality rates following AMI was significantly attenuated following adjustment for age and pre-existing cardiovascular events or conventional vascular risk factors, suggesting that the strength of the income-mortality association could be lessened through the management of known risk factors for ischemic heart disease among people of less economic affluence(68).

Studies have since emerged from the provinces of Quebec(69-71) and Alberta(72) that have described variations in management of patients with IHD similar to those seen in Ontario. Rodrigues *et al.* demonstrated considerable variation in procedure utilization rates in the initial 10 days post-acute MI in the province of Quebec(69), while Vanasse *et al.* showed revascularization rates in Quebec that differed according to the distance between the patient's geographic place of residence and the nearest specialized cardiology centre(70). Pilote *et al.* has also uncovered the stark SES gradient that existed in Quebec in access to cardiac catheterization and coronary revascularization following an acute MI and highlighted how patients in low SES areas were less likely to undergo cardiac catheterization(71).

1.5 Access to Care in Nova Scotia

The province of Nova Scotia has among the highest prevalence rates of potentially modifiable cardiovascular disease risk factors(73, 74) and among the highest rates of cardiovascular disease and IHD-related mortality in Canada(75). The resulting burden on the provincial health care system is substantial; yet, despite the considerable resources invested in the treatment of IHD in Nova Scotia, very little is known as to whether or not access to cardiac care and outcomes among patients with IHD in this province are in fact uniform.

Unlike Ontario, Quebec and Alberta, Nova Scotia is unique in that it is a smaller province from the standpoint of population (approximately 900 000 persons) and surface area (approximately 55 000 km^2) and it is served by a single, centralized tertiary cardiac care centre located in Halifax. There, cardiac catheterization and coronary revascularization procedures for the entire province are performed. Currently, only those inhabitants of the greater Halifax regional municipality with symptomatic IHD are likely to gain direct access to the single tertiary care centre. The remainder of the population, those from the non-metropolitan urban and rural areas of Nova Scotia, generally access the health care system via regional and community hospitals and require a transfer to the tertiary care centre before being considered for invasive cardiac testing and possible revascularization. Studies performed by the Canadian Cardiovascular Outcomes Research Team(76) have identified that considerable inter-regional variability exists within Nova Scotia regarding the type of physician seen by patients admitted with an acute cardiac condition (general practitioner/family doctor vs. cardiologist/general internist)(77) as well as the rates of cardiac catheterization and coronary revascularization(78, 79). One would thus expect that such a system would be susceptible to the same province-wide socioeconomic and/or geographic gradients in access to care as are found in the larger Canadian provinces.

In a study of 2 116 Nova Scotians enrolled in the 1990 Nova Scotia Nutrition Survey, Veugelers *et al.* found that individual income and education, independent of neighbourhood socioeconomic characteristics, were strongly associated with mortality such that poorly-educated and lower-earning individuals experienced diminished overall survival(80). Veugelers *et al.* also found, in separate studies, that socioeconomic status and geographic place of residence affected utilization rates of family physician, specialist and hospital services(81, 82). The only study to date that has specifically looked at access to care in Nova Scotia in the setting of cardiovascular disease was conducted by Mayich *et al.*(83) Of the 707 patients who were admitted to hospital in Nova Scotia with an acute MI complicated by cardiogenic shock between October 1997 and December 2002, only 414 or 59% were either admitted directly or eventually transferred to the sole tertiary cardiac care centre, and of these, only 250 (35%) received cardiac catheterization. Following adjustment for baseline demographic and clinical characteristics, access to the tertiary cardiac care centre was found to be an independent predictor of survival.

Little is known regarding access to cardiac care and associated clinical outcomes in Nova Scotia. The delivery of health care of Nova Scotia differs considerably from that of Ontario, Quebec or Alberta such that data from these provinces are not applicable to

Nova Scotia. Nova Scotia is unique in that for a province with a single tertiary cardiac care center, it has very well-developed observational and administrative data sources. Thus, Nova Scotia is extraordinarily well-suited to studying the delivery of care in highly centralized delivery care system.

With the sizeable burden of cardiovascular disease in this province and the significant resources invested in its treatment, it is of great importance that we establish whether or not inequalities in access to cardiac care exist in Nova Scotia and the roles that sex, SES and geography play in affecting such access. In this thesis, rich observational and administrative data have been used with the support of traditional as well as non-traditional statistical methodologies to gain greater insight into complex relationship underlying sex, SES, geography and cardiovascular care in Nova Scotia. While not explicitly a socioeconomic or geographic characteristic, sex is increasingly being recognized as a critical socio-demographic variable that may impact on both access to care and clinical outcomes in patients with ischemic heart disease and is thus considered independently. The thesis is made up of the following manuscripts:

1. Women have worse long-term outcomes after coronary artery bypass grafting than men
2. The effect of place of residence on access to invasive cardiac services following acute myocardial infarction
3. Geography and long-term outcomes following coronary artery bypass grafting
4. Socioeconomic and geographic determinants of readmission: a population-based, multi-level analysis

Chapter 2: Women Have Worse Long-Term Outcomes after Coronary Artery Bypass Grafting than Men

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2.1 Introduction

Numerous studies have reported higher rates of in-hospital mortality in women undergoing coronary artery bypass grafting (CABG)(84-101) as well as greater post-operative morbidity in the form of prolonged ventilation(102-106), extended post-operative length of stay(103-107), greater frequency of 30-day readmission to hospital following initial discharge(108), poorer physical and psychological recovery(103, 109) and diminished quality of life(110-112).

The relatively poor in-hospital outcomes experienced by women have been attributed to the observation that women present for CABG with more advanced symptoms and a greater number of diseased coronary vessels(84-89, 92-101, 107, 108), a smaller body surface area(89, 98) and coronary arteries of smaller diameter(95, 98). These findings may partially be explained by the delayed diagnosis of ischemic heart disease (IHD) in women, particularly those with atypical symptom patterns(113-116), the decreased referral of women for non-invasive and invasive diagnostic testing(117-125), the decreased sensitivity and specificity of certain non-invasive tests in women(126) and the perception among men and women alike that IHD is not a disease that affects women(127).

The impact of female sex on long-term survival and freedom from adverse outcomes following CABG, however, is not as well established. Some studies have shown that long-term survival and freedom from symptom recurrence is diminished in women(84, 128, 129) while others have shown that women enjoy long-term survival following

CABG that is similar to if not better than that of men(93, 95, 96, 130-137). The objective of this study was to compare long-term results in men and women undergoing isolated, on-pump CABG in Nova Scotia, Canada.

2.2 Methods

2.2.1 Population

All residents of Nova Scotia having undergone isolated, on-pump CABG at the Queen Elizabeth II (QEII) Health Sciences Centre from March 1, 1995, until December 31, 1999, were identified using the Maritime Heart Centre (MHC) database. From this group, those patients whose records could be linked to national and provincial administrative databases for long-term follow-up until March 31, 2000, made up the final study population. The QEII Health Sciences Centre is the sole tertiary, cardiac care centre serving the entire province of Nova Scotia as well as parts of New Brunswick, Prince Edward Island and Newfoundland, and all patients from the province of Nova Scotia requiring cardiac surgery are referred to this centre.

2.2.2 Data Sources

The MHC database captures detailed information on a wide range of pre-operative, intra-operative, and in-hospital post-operative variables including post-operative complications and in-hospital mortality for all patients undergoing cardiac surgery at the QE II Health Sciences Centre in Nova Scotia, Canada. It is audited on an annual basis to ensure data accuracy, and it guarantees the anonymity and confidentiality of its patients by creating a dataset for analysis which is stripped of all patient identifiers. Linkages to other databases (e.g. administrative databases) are carried out via an encrypted identifier that prevents the identification of any individual patient.

The MHC database was linked to the Canadian Institute for Health Information (CIHI) Discharge Abstract Database and the Nova Scotia Vital Statistics database. The CIHI Discharge Abstract Database is a national database that contains extensive data for each inpatient and outpatient hospital visit in Nova Scotia and enables us to track all readmissions to hospital. The Nova Scotia Vital Statistics database collects information on all births and deaths occurring within the province of Nova Scotia.

2.2.3 Variable Selection

Pre-operative variables of interest included age (as a continuous variable), sex, body mass index or BMI (BMI > 25 kg/m^2 vs. BMI ≤ 25 kg/m^2), smoking history, diabetes, hypercholesterolemia, hypertension, renal insufficiency (pre-operative serum creatinine (Cr) of ≥ 176 μmol/L), peripheral and cerebrovascular disease, history of previous open heart surgery, left ventricular ejection fraction or EF (assessed dichotomously as EF < 40% vs. EF ≥ 40%), New York Heart Association (NYHA) functional classification (NYHA class IV vs. NYHA classes I – III), recent myocardial infarction (MI) (defined as the occurrence of an MI in the 21 days prior to surgery), urgency status (operation performed within 24 hours from the time of referral vs. operation performed at a time interval of greater than 24 hours from the time of referral) and number of diseased vessels (triple-vessel or left main disease vs. single- or double-vessel disease). Intra-operative variables of interest included left internal mammary artery (LIMA) use, number of distal anastomoses, cross clamp time and total bypass time. The long-term outcomes of interest included all-cause mortality following discharge from hospital, readmission to hospital for any cardiac cause as defined by the following codes from the ninth revision of the International Classification of Disease, Clinical Modification (ICD-9-CM): 410 (acute MI), 411 (unstable angina), 412 (old MI), 413 (angina pectoris), 414 (other forms of chronic IHD), 426 (conduction disorders), 427 (cardiac dysrrhythmias), 428 (heart failure), and 429 (ill-defined descriptions and complications of heart disease), and a composite outcome defined as all-cause mortality following discharge from hospital or readmission to hospital for any cardiac cause.

2.2.4 Statistical Analysis

Univariate comparisons between men and women based on pre-, intra-, and post-operative variables were carried out using Chi-square tests for dichotomous variables and two-tailed t-tests for continuous variables. Unadjusted Kaplan-Meier survival curves were generated for those patients who were successfully discharged from hospital to assess the effect of female sex on long-term all-cause mortality, readmission to hospital for any cardiac cause, and the long-term composite outcome. A fully-adjusted Cox proportional hazard model was created to determine the impact of female sex on the long-term composite outcome of interest after adjusting for differences between patients in clinical presentation. Pre-operative variables regardless of whether or not they differed between men and women were included as variables in the model selection process. A parsimonious model was then created using a backward elimination analysis which retained only variables significant at $p < 0.05$. All statistical analyses were performed using the SAS statistical analysis software package version 8.2 (SAS, Cary, North Carolina).

2.3 Results

A total of 3422 patients from Nova Scotia underwent isolated, on-pump CABG surgery at the QEII Health Sciences Centre between March 1, 1995, and December 31, 1999. From this group, 3404 patients, including 2511 men and 893 women, were linked successfully to Nova Scotia provincial administrative databases for long-term follow-up until March 31, 2000. These patients formed the final study population.

When compared to men, women were older and were more likely to have hypertension, diabetes, hypercholesterolemia, and a body mass index greater than 25 kg/m^2. Women were also more likely to present for surgery with history of a recent MI, NYHA functional class IV symptoms and an urgent or emergent status. On the other hand, women were less likely to have a history of smoking or previous cardiac operation or to have left main or triple vessel coronary disease. No significant differences were found between men and women in rates of pre-operative left ventricular dysfunction, pre-operative renal failure, and peripheral vascular disease (Table 2.1).

Intra-operatively, compared to men, women received fewer bypasses and experienced shorter cross clamp times and shorter total bypass times. Furthermore, they were less likely to receive a LIMA graft than men (Table 2.2).

Table 2.1: Pre-operative characteristics for each sex in patients undergoing CABG

Variable	**Women**	**Men**	**Odds Ratio**	**95% CI**	**p value**
Mean age (years)	67.8	64.2	-	-	<0.0001
BMI > 25 kg/m^2	25.9%	20.0%	1.40	(1.17, 1.67)	0.0002
Smoking history	51.6%	75.4%	0.35	(0.30, 0.41)	<0.0001
Diabetes	38.0%	28.0%	1.57	(1.34, 1.84)	<0.0001
Hypercholesterolemia	62.9%	56.9%	1.29	(1.10, 1.51)	0.002
Hypertension	68.7%	53.7%	1.94	(1.65, 2.29)	<0.0001
Pre-operative renal failure (serum Cr > 176 mmol/L)	6.9%	5.5%	1.28	(0.94, 1.75)	0.11
Peripheral and/or cerebrovascular disease	23.2%	22.3%	1.05	(0.88, 1.26)	0.59
Previous open heart surgery	4.3%	8.1%	0.50	(0.35, 0.72)	0.0001
EF > 40%	10.9%	11.7%	0.93	(0.73, 1.18)	0.55
NYHA class IV	51.2%	44.0%	1.33	(1.14, 1.55)	0.0002
Recent MI	12.1%	9.2%	1.35	(1.06, 1.72)	0.01
Urgent / emergent status	23.7%	16.3%	1.60	(1.32, 1.93)	<0.0001
Left main/triple vessel disease	77.0%	81.0%	0.79	(0.65, 0.94)	0.01

Table 2.2: Intra-operative characteristics for each sex in patient undergoing CABG

Variable	**Women**	**Men**	**p value**
Mean number of bypasses	3.0	3.3	<0.0001
LIMA graft use	80.6%	86.2%	0.0001
Cross-clamp time	61 min	68 min	<0.0001
Total bypass time	101 min	108 min	<0.0001

While differences in rates of in-hospital mortality and long-term all-cause mortality between women and men did not reach statistical significance, readmission to hospital for any cardiac cause and the long-term composite outcome of interest (mortality or readmission) demonstrated significant differences (Table 2.3, Figures 2.1-2.3). Before adjustment, female sex was a significant predictor of long-term adverse outcomes over time (HR 1.33, p = 0.0001). After adjusting for differences in clinical presentation between men and women using Cox proportional hazards modeling techniques, female sex remained an independent predictor of long-term adverse outcomes over time (adjusted HR 1.18, p=0.03) (Table 2.4).

2.4 Discussion

Numerous studies have shown that women experience greater operative mortality following CABG than do men(84-101). The negative outcomes associated with female sex may be attributed in part to the advanced symptoms and greater coronary disease severity of women at the time of surgery(84-89, 92-101, 107, 108), their smaller body surface area(89, 93, 98) and their decreased coronary vessel diameter(95, 98). However, even after adjusting for these differences, sex still emerged as an independent predictor of operative mortality following CABG(84, 86-92).

The results of studies looking at long-term outcomes following CABG in women are distinctly more varied. Richardson *et al.* noted that five-year overall survival (91% vs. 82%, p = 0.008) and event-free survival (absence of cardiac death, myocardial infarction, or recurrent angina pectoris) (67% vs. 43%, p = 0.03) were superior among men(84). Douglas *et al.*(128) and Loop *et al.*(129) similarly found that at late follow-up, men were more likely to be free of angina. On the other hand, others have shown that long-term results in men and women following CABG are similar (93, 95, 96, 130-134).

Table 2.3: Comparison of short-term and long-term outcomes in men and women undergoing CABG

Outcome	**Women**	**Men**	**Odds Ratio**	**95% CI**	**p value**
Short-term					
In-hospital mortality	2.9%	2.2%	1.34	(0.83, 2.15)	0.22
Long-term					
All-cause mortality	8.3%	6.6%	1.29	(0.97, 1.72)	0.08
Readmission to hospital	25.8%	19.8%	1.41	(1.17, 1.69)	0.0002
Composite outcome	30.2%	23.5%	1.41	(1.19, 1.68)	<0.0001

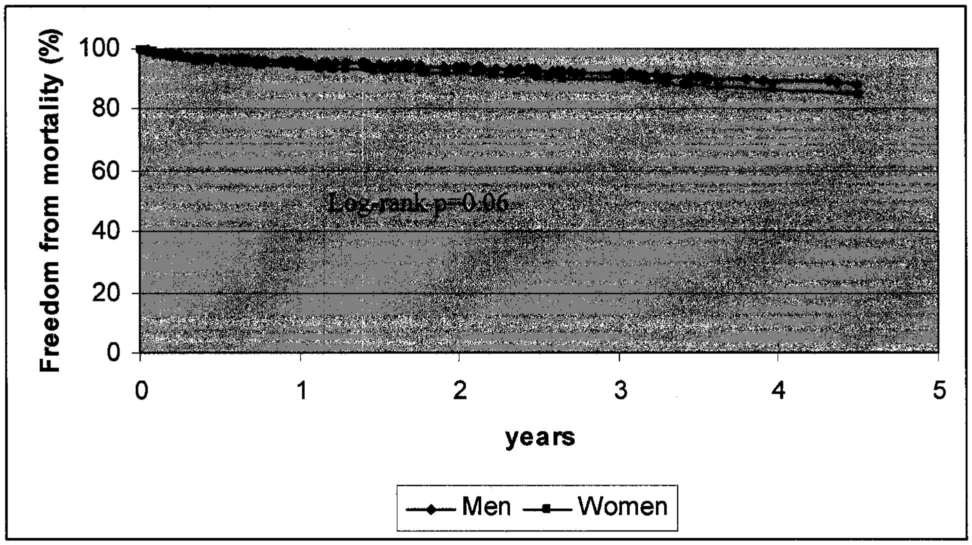

Figure 2.1: Unadjusted Kaplan Meier survival curves comparing all-cause mortality following initial discharge from hospital between men and women in patients undergoing CABG

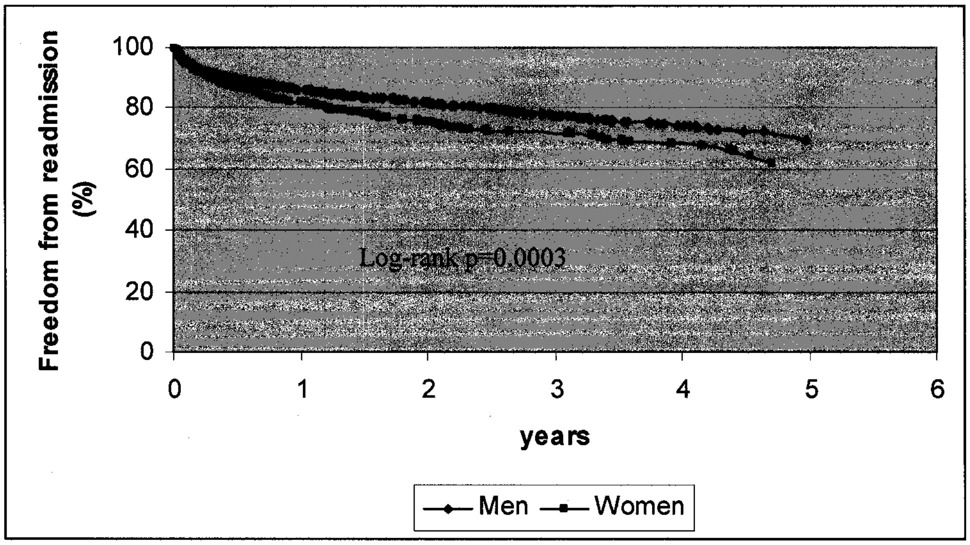

Figure 2.2: Unadjusted Kaplan Meier survival curves comparing readmission to hospital for any cardiac cause between men and women in patients undergoing CABG

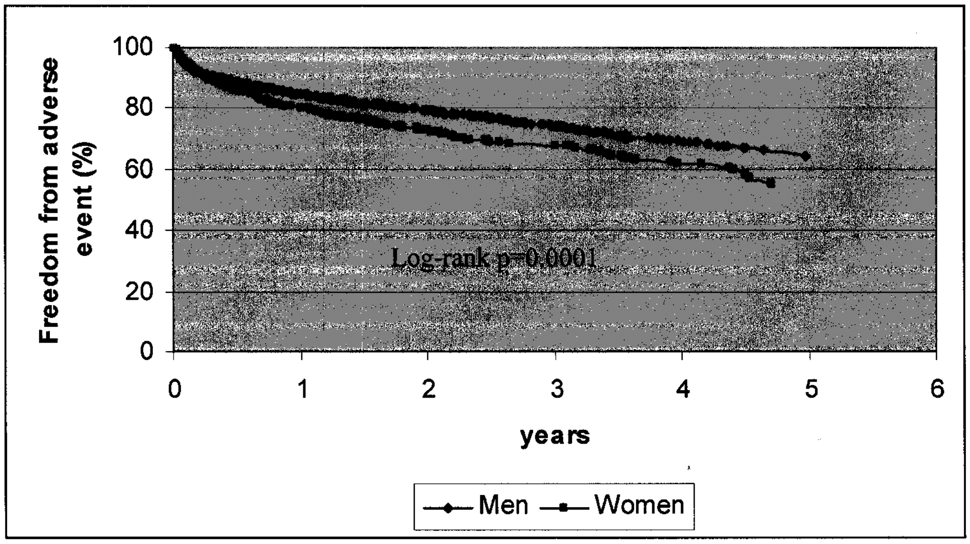

Figure 2.3: Unadjusted Kaplan Meier survival curves comparing composite outcome between men and women in patients undergoing CABG

Table 2.4: Cox proportional hazards analysis modeling for long-term composite outcome (all-cause mortality and readmission for cardiac cause) over time in patients undergoing CABG

Variable	**HR**	**95% CI**	**p-value**
Female sex	1.18	(1.02, 1.36)	0.03
Age (years)	1.02	(1.01, 1.03)	<0.0001
Diabetes	1.36	(1.19, 1.56)	<0.0001
Pre-op renal failure	1.60	(1.26, 1.96)	<0.0001
Peripheral and/or cerebral vascular disease	1.37	(1.18, 1.58)	<0.0001
EF < 40%	1.79	(1.51, 2.13)	<0.0001
Previous open heart surgery	1.63	(1.32, 2.02)	<0.0001
NYHA class IV	1.27	(1.10, 1.47)	0.001
Urgent / emergent status	1.58	(1.34, 1.85)	<0.0001

More recently, studies have begun to report on the superior long-term survival of women after CABG(135-137). Abramov *et al.* from Ontario, Canada noted that long-term survival following CABG was superior among women (93.1% vs. 90.0%) and that female sex was in fact protective for late survival after adjustment for other risk variables (HR 0.40, $p < 0.005$)(135). Jacobs *et al.*, using data from the Bypass Angioplasty Revascularization Investigation (BARI) Trial, also found that female sex was an independent predictor of improved 5-year survival following CABG and percutaneous coronary intervention (PCI) after controlling for multiple risk factors (HR 0.60, $p = 0.003$)(136). The results from our study indicate that although women experienced rates of long-term all-cause mortality comparable to those of men (8.3% vs. 6.6%, $p = 0.08$), they were significantly more likely than men to experience a long-term adverse event after CABG (30.2% vs. 23.5%, $p < 0.0001$). Following adjustment for differences in clinical presentation, female sex still remained an independent predictor of adverse long-term outcomes after CABG (HR 1.18, $p = 0.03$).

When presenting for surgery, women in our study were older than men and were more likely to have hypertension, diabetes, hypercholesterolemia and a body mass index greater than 25 kg/m^2. Women were also more likely to present for surgery with NYHA functional class IV symptoms and to require an operation on an urgent or emergent basis. However, even after adjustment for differences in clinical presentation, female sex still emerged as an independent predictor of adverse long-term outcomes, signifying that advanced symptoms at the time of surgery does not fully explain the impact of sex. This enduring effect of female sex may be attributed to a number of factors. First of all, women in Nova Scotia have been shown to have significantly lower adjusted rates of cardiac catheterization in the first 6 months following admission for an acute MI(138). Diminished access to invasive cardiac care likely results in their delayed referral for CABG which, in turn, may translate into advanced symptoms and a more urgent need for surgery. However, differences in access to cardiac catheterization care may also reflect more pervasive sex-based differences in the management of IHD. For instance, women in Nova Scotia with symptoms of IHD may seek treatment much later, receive fewer medications at lower doses and be subject to less rigorous follow-up than their male counterparts, leading to a clinically more advanced presentation at time of surgery that may not be adequately measured in terms of comorbidities, symptoms and level of urgency alone. Secondly, women undergoing CABG in our study received fewer bypasses and were less likely to receive a LIMA graft than men. Despite the fact that women were less likely than men to have three-vessel or left main disease, the construction of fewer bypass grafts in women likely reflects the greater degree of incomplete revascularization among women whether it be secondary to increased diffuseness of coronary disease or smaller coronary diameter. This may have accounted in part for the increased rates of long-term adverse outcomes. Furthermore, the long-term mortality and morbidity benefits of the LIMA graft to the left anterior descending artery have been demonstrated in a number of clinical studies(139-141). While the decreased utilization of the LIMA graft in women in our study may be related to the increased proportion of women who came for surgery with either an urgent or emergent status, it does not obviate the negative impact that fewer LIMA grafts have on rates of long-term mortality and readmission to hospital for any cardiac cause. Finally, women may experience substandard long-term post-operative clinical follow-up, receive less teaching around minimizing or eradicating risk factors for IHD and be prescribed have lower rates of disease-modifying medications including anti-platelet and lipid-lowering agents.

Our study has certain limitations. First of all, in any study that uses retrospectively-collected observational data as its primary source of information, one is limited to risk-adjusting using only those clinical variables that have been measured. Unmeasured confounders that have not been adjusted for may account, to some extent, for the long-term differences seen between men and women undergoing CABG. Secondly, as alluded to earlier, there was a lack of detailed information available on the long-term post-operative management of women who have undergone CABG. Differences in medication use, consistency of clinical follow-up and risk factor control may serve to explain the increased rates of readmission to hospital for any cardiac cause over time. Finally, this study is limited by a lack of power to assert the null hypothesis when comparing in-hospital adverse outcomes between men and women. Collecting data from multiple Canadian cardiac surgical centres will enable us to better assess the impact of sex on short-term outcomes following CABG.

As the rates of hospitalization for IHD and CABG continue to rise among women in Canada(127, 135, 142), the need to understand why women experience inferior long-term outcomes following CABG within a single-tiered, universal-access, publicly-funded health care system becomes even greater. Sex inequalities in medical management and rates of diagnostic and therapeutic intervention must be addressed, and disparities relating to social class, economic status, and cultural background, must be factored into consideration when attempting to comprehend differences in outcomes.

2.5 Conclusion

In Nova Scotia, between 1995 and 1999, women presented for isolated, on-pump CABG with more co-morbid illness, more advanced symptoms, and greater urgency than men. Intra-operatively, they received fewer bypasses and were less likely to receive a LIMA graft. While rates of in-hospital and long-term mortality were comparable between men and women, a significantly greater percentage of women experienced long-term adverse outcomes following surgery. After adjusting for differences in clinical presentation, female sex was still found to be an independent predictor of long-term adverse outcomes after CABG.

Chapter 3: The Effect of Place of Residence on Access to Invasive Cardiac Services Following Acute Myocardial Infarction

3.1 Introduction

The Canadian public health care system is a universal health care system mandated to provide reasonable access to quality health care for all Canadians regardless of age, sex, race, socioeconomic status or place of residence(61). However, a growing number of studies have shown that significant inequalities may exist within such a system, especially in relation to access to invasive cardiac care following an acute myocardial infarction (MI)(65-67, 69, 71, 72, 79, 143-147). Alter *et al.* demonstrated that increases in neighbourhood income from the lowest to the highest quintile were associated with a 23% increase in rates of cardiac catheterization following an acute MI and a 45% reduction in waiting times in the province of Ontario(65). Similarly, Rodrigues *et al.* established marked regional variation in rates of cardiac procedures in patients who experienced an acute MI in the province of Quebec(69). Seidel *et al.* were able to show that patients living at greater distances from cardiac catheterization facilities in the province of Alberta had lower adjusted rates of cardiac catheterization(72). While it is becoming increasingly evident that inequalities exist in access to cardiac care across Canada, little is known regarding the effect of such inequalities on long-term rates of mortality and readmission to hospital.

In provinces such as Quebec, Ontario and Alberta, invasive cardiac services are provided by multiple cardiac catheterization and revascularization centres. By contrast, Nova Scotia, with a population of less than 1 million people, possesses a single, centralized, tertiary cardiac care centre that offers cardiac catheterization, percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG) services for the entire province. Thus, Nova Scotia provides an ideal setting in which to examine the impact of place of residence on rates of cardiac catheterization following admission for acute MI and to explore its effect on long-term rates of all-cause mortality and readmission to hospital.

3.2 Methods

3.2.1 Data Sources

Data were obtained from the Improving Cardiovascular Outcomes in Nova Scotia (ICONS) database, a population-based, province-wide clinical registry. From October 15, 1997 until the present, this registry has captured information on all hospitalizations across Nova Scotia for select cardiovascular diseases including acute MI(148, 149). In addition to possessing detailed data relating to patient demographic characteristics and co-morbid illnesses, the ICONS database tracks discharge drug prescriptions, in-hospital and out of hospital procedure use (cardiac catheterization, PCI, CABG and heart valve surgery) and such outcome data as all-cause mortality and readmission to hospital for various cardiac causes problems including non-fatal MI, unstable angina or CHF.

3.2.2 Study Population

All patients admitted to a hospital in the province of Nova Scotia with a discharge diagnosis of an acute MI between April 1, 1998 and December 31, 2001 were identified using the ICONS database. Any patient who had been admitted with an acute MI in the six months prior to their "index" admission was excluded as was anyone who was not a resident of Nova Scotia. The remaining patients formed the final study population.

3.2.3 Socioeconomic Information

Because ICONS database does not capture self-reported income data on all patients, we relied on 2001 Canadian census data to determine the median individual income level of the neighbourhood or dissemination area best corresponding to a patient's place of residence. This was done by linking a patient's postal code to a census dissemination area using the Postal Code Conversion File(150). As a result, each patient was assigned a median individual income as an estimate of their actual income. This method of employing ecologic-level measures of income where access to individual-level income measures is lacking has previously been validated(151, 152). Income quintiles were generated using dissemination area-level median individual incomes from across the province and are shown here (as expressed in Canadian dollars): lowest: $7392 – $14 844; second: $14 865 – $17 067; middle: $17 097 – $19 984; fourth: $19 986 – $24 617; and highest: $24 675 - $53 946. Patients were placed into one of these quintiles on the basis of their estimated income.

3.2.4 Geographic Information

The first three digits of six-digit postal codes, referred to as forward sortation areas, were used to determine the patient's place of residence (Figure 3.1). Forward sortation areas with '0' as the second digit, indicative of areas with fewer than 1 000 persons, were deemed rural areas (RA), while those with a second digit other than '0' were considered urban areas(153). Among neighbourhoods defined as urban areas, those located within or directly adjacent to the metropolitan area of Halifax, Nova Scotia were designated metropolitan areas (MA), and those located outside of greater Halifax were designated non-metropolitan urban areas (UA). Halifax is the site of the sole tertiary cardiac care centre, the Queen Elizabeth II (QE II) Health Sciences Centre, providing cardiac catheterization, PCI and CABG services for the entire province of Nova Scotia. Patients from MA live closest to this tertiary care centre while patients living within UA are closest to medium-sized regional hospitals and those living within RA are closest to small-sized community hospitals.

3.2.5 Statistical Analysis

Comparisons across the three geographic groupings using chi-squared tests and two-sided t-tests were made on the basis of several demographic, clinical, socioeconomic and geographic variables. These included age, sex, co-morbid illness, history of prior coronary intervention and type of acute MI (ST segment elevation vs. non-ST segment elevation). Rates of acute intervention including thrombolysis and primary PCI within the first 24 hours following admission were considered. Because not all patients can be accommodated during their index hospitalization, we also examined and compared rates of cardiac catheterization within the first six months after admission and rates of revascularization by either PCI or CABG in the first year following admission in those

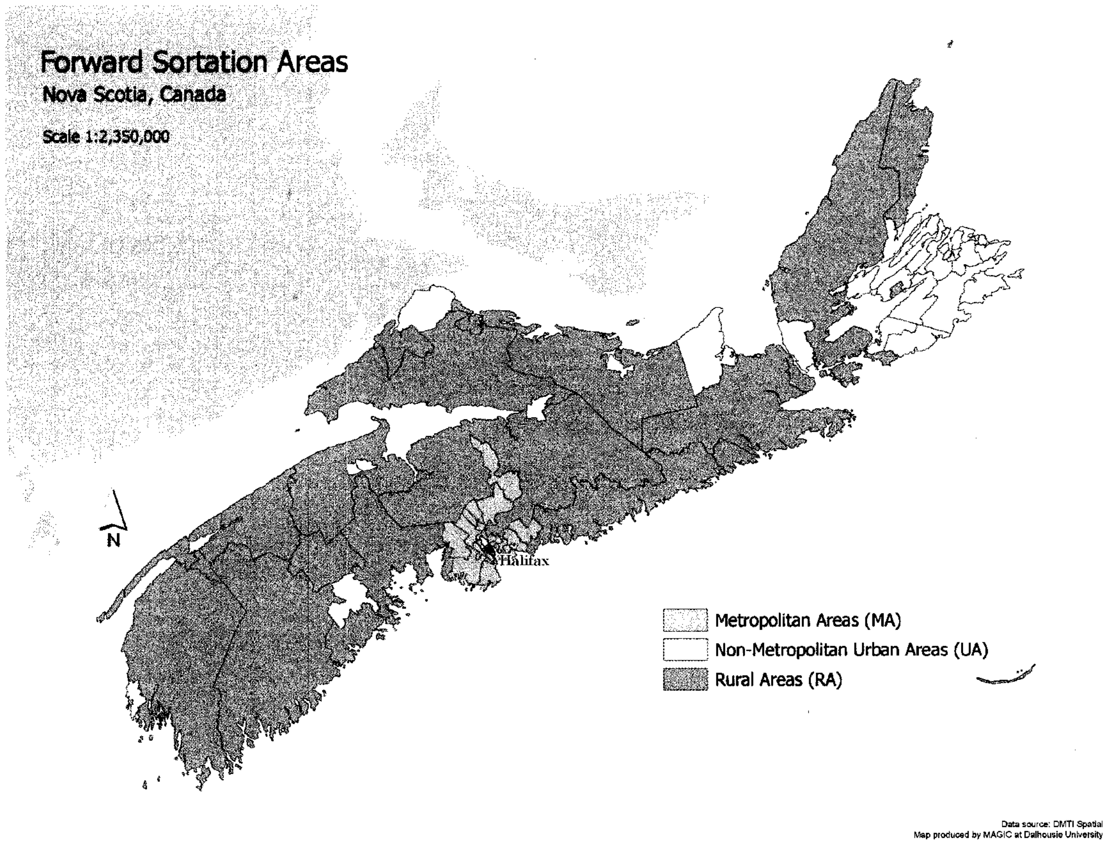

Figure 3.1: Geographic groupings in Nova Scotia based on forward sortation area

patients having undergone a cardiac catheterization within the first six months. Additional variables compared across strata included rates of non-invasive investigations performed during the same admission (including exercise stress testing, echocardiography, nuclear scintigraphy and wall motion studies). We compared rates of discharge drug prescriptions (including β-blockers, angiotensin converting enzyme (ACE) inhibitors, angiotensin-II receptor blockers (ARB), 3-hydroxy-3-methylglutaryl (HMG) coenzyme A reductase inhibitors ("statins") and anti-platelet agents including acetylsalicylic acid, clopidogrel and ticlodipine) in those patients discharged alive from hospital. Finally, we examined differential income distribution, distance from the index hospital of admission to the QE II Health Sciences Centre, level of admitting facility (community, regional or tertiary) and specialty of admitting physician (cardiologist, general internist, general practitioner or other). Waiting times from the time of admission to the time of catheterization as well as from the time of cardiac catheterization to the time of revascularization were evaluated across geographic groupings using two-sided t-tests, cumulative survival plots and log-rank tests. Unadjusted rates of all-cause mortality, readmission to hospital for any cardiac cause and readmission to hospital for either acute MI, unstable angina or CHF at one-year and over the longer term were also calculated.

The risk-adjusted impact of place of residence on rates of cardiac catheterization was determined using Cox proportional-hazard models that were fully adjusted for age, gender, co-morbid illness, type of acute MI, whether or not the patient received thrombolytic therapy post-acute MI and income level. The risk-adjusted impact of place of residence on long-term rates of all-cause mortality and readmission to hospital was determined through the development of separate Cox proportional-hazard models that were fully adjusted for age, gender, co-morbid illness and income level.

Statistical significance was indicated by a p-value of less than 0.05 in our analyses, all of which were performed using the SAS software package version 8.2 (SAS, Cary, North Carolina).

3.3 Results

Between April 15, 1998 and December 31, 2001, 7351 patients were admitted to hospital across Nova Scotia with a discharge diagnosis of acute MI. Of these, 2113 belonged to MA (age- and sex-adjusted rate 247.2 / 100 000 persons / year), 2114 to UA (242.0 / 100 000 persons / year) and 3124 to RA (226.2 / 100 000 persons / year). Residents of MA were most likely to be admitted to the QE II Health Sciences Centre, residents of UA were most likely to be admitted to a regional health care facility and residents of RA were more predominantly admitted to a community hospital (Table 3.1). The majority of patients in Nova Scotia were admitted under the care of either a general internist or general practitioner, regardless of place of residence. However, a greater percentage of patients from MA were primarily cared for by a cardiologist than those from either UA or RA (Table 3.1).

Patients who resided in MA were more likely to be female and to have a history of smoking, hypercholesterolemia, hypertension, chronic obstructive pulmonary disease (COPD) and/or asthma, renal failure, CHF and prior PCI or CABG (Table 3.1). They were less likely to have experienced an ST-segment elevation acute MI (Table 3.1) and were subjected to lower rates of thrombolytic therapy (Table 3.2). Yet, this cohort had significantly higher rates of primary PCI, exercise stress testing, echocardiography and nuclear scintigraphy (Table 3.2). They also had higher rates of prescribed cardiac medications on discharge, including prescriptions for ACE inhibitors / ARB, HMG coenzyme A reductase inhibitors and anti-platelet agents (Table 3.2). Furthermore, they

Table 3.1: Comparison of baseline patient, physician and hospital characteristics across geographic groupings in patients admitted for acute MI

Variable	**MA**	**UA**	**RA**	**p-value**
Age				0.46
> 70	46.1	47.7	46.6	
61 - 70	23.3	21.8	22.3	
51 - 60	28.4	19.7	18.6	
≤ 50	12.0	10.8	12.5	
Female sex	39.8	37.8	35.6	0.009
Smoking history	63.0	62.6	59.5	0.01
Hypercholesterolemia	37.2	34.8	33.1	0.01
Diabetes	27.2	27.9	26.3	0.45
Hypertension	54.5	51.6	50.0	0.006
Congestive heart failure	12.6	11.2	10.2	0.02
Previous MI / unstable angina	27.7	29.1	27.3	0.34
COPD / asthma	19.2	16.1	16.1	0.006
Renal failure	7.1	3.8	3.5	<0.0001
Cerebrovascular disease	11.8	10.8	9.9	0.09
Prior CABG / PCI	11.5	10.2	9.2	0.03
ST-elevation MI	42.0	45.6	46.3	0.006
Income quintile				<0.0001
Lowest	8.9	30.9	16.4	
Second	6.9	27.6	31.4	
Middle	14.3	22.7	39.1	
Fourth	27.5	15.7	10.4	
Highest	42.5	3.2	2.7	
Distance from tertiary centre				<0.0001
0 - 70 km	97.3	3.1	19.4	
71 - 163 km	1.7	31.4	42.8	
> 163 km	1.1	65.6	37.8	
Admitting hospital type				<0.0001
Community	0.6	5.0	18.6	
Regional	29.1	92.4	71.3	
Tertiary	70.4	2.6	10.1	
Attending physician				<0.0001
Cardiologist	19.2	4.8	3.6	
General internist	51.3	58.7	52.0	
General practitioner	24.3	32.7	41.1	
Other	5.2	3.8	3.3	

had higher rates of and shorter wait times for cardiac catheterization during the first six months following admission (Table 3.2, Figure 3.2). Following cardiac catheterization, there was no difference in rates of coronary revascularization, by either PCI or CABG, across the geographic groupings, and there was no significant difference in wait times from cardiac catheterization to coronary revascularization (Table 3.2).

After adjusting for differences between patients in terms of age, sex, co-morbid illness, type of acute MI, whether or not the patient received thrombolytic therapy post-acute MI and income level, residence in either UA or RA emerged as an independent predictor of lower rates of cardiac catheterization within the first six months following admission for acute MI (Table 3.3).

While long-term rates of all-cause mortality did not differ between the three geographical groupings (Table 3.4, Figure 3.3), patients who resided in either UA or RA experienced higher long-term rates of readmission to hospital for any cardiac cause (Table 3.4, Figure 3.4). After adjustment for differences between patients in terms of age, sex, co-morbid illness and income quintile, residence in either UA or RA emerged as an independent predictor of increased long-term rates of readmission to hospital for any cardiac cause (Table 3.5). When this analysis was repeated using only the composite of readmission for acute MI, unstable angina or CHF as the long-term outcome of interest, residence in UA emerged as an independent predictor of this endpoint (HR 1.19, 95% CI 1.05, 1.35) while residence in RA did not (HR 1.03, 95% CI 0.91, 1.17).

Table 3.2: Invasive, non-invasive and pharmacological management of patients admitted for acute MI

Variable	MA	UA	RA	p-value
Invasive				
Thrombolysis (%)	27.7	33.2	34.2	<0.0001
Primary PCI (%)	7.3	1.3	1.7	<0.0001
Rate of cardiac catheterization (%)	45.6	37.3	37.3	<0.0001
Time to cardiac catheterization (days)	15.0	32.1	28.7	<0.0001
Rate of CABG / PCI (%)	72.2	75.2	73.5	0.35
Time from admission to revascularization (days)	28.8	51.5	44.5	<0.0001
Time from catheterization to revascularization (days)	16.5	22.0	19.0	0.05
Non-invasive				
Exercise stress test (%)	47.0	41.1	41.7	<0.0001
Echocardiography (%)	24.9	24.1	17.6	<0.0001
Scintigraphy (%)	4.6	3.4	3.1	0.02
Wall motion study (%)	13.4	11.4	16.4	<0.0001
Discharge medications				
β-blockers (%)	87.9	86.6	86.8	0.44
ACE inhibitors / ARB (%)	63.1	60.9	57.7	0.0008
HMG coenzyme A reductase inhibitors (%)	55.1	48.6	46.1	<0.0001
Anti-platelet agents (%)	91.1	89.2	88.7	0.03

Table 3.3: Multivariate predictors of cardiac catheterization in the first six months following admission for acute MI

Variable	HR	95% CI	p-value
Age			
> 70	0.54	(0.47, 0.61)	<0.0001
61 - 70	0.90	(0.79, 1.02)	0.08
51 - 60	0.96	(0.85, 1.09)	0.52
≤ 50	1.00	-	-
Female sex	0.84	(0.77, 0.91)	<0.0001
Smoking history	1.06	(0.97, 1.15)	0.21
Hypercholesterolemia	1.50	(1.39, 1.63)	<0.0001
Diabetes	1.01	(0.93, 1.11)	0.79
Hypertension	1.16	(1.07, 1.25)	0.0003
Congestive heart failure	0.60	(0.50, 0.71)	<0.0001
Previous MI / unstable angina	1.06	(0.97, 1.17)	0.21
COPD / asthma	0.74	(0.66, 0.83)	<0.0001
Renal failure	0.67	(0.53, 0.86)	0.001
Cerebrovascular disease	0.66	(0.57, 0.78)	<0.0001
Prior CABG / PCI	1.21	(1.07, 1.38)	0.003
ST-elevation MI	1.07	(0.94, 1.21)	0.31
Thrombolysis	0.99	(0.87, 1.13)	0.88
Income			
Quintile 1	1.00	-	-
Quintile 2	1.14	(0.99, 1.31)	0.07
Quintile 3	1.11	(0.96, 1.28)	0.17
Quintile 4	0.97	(0.84, 1.14)	0.74
Quintile 5	0.89	(0.76, 1.04)	0.14
Geography			
RA	0.75	(0.67, 0.84)	<0.0001
UA	0.77	(0.69, 0.87)	<0.0001
MA	1.00	-	-

Table 3.4: Unadjusted one-year and long-term rates of mortality and readmission in patients admitted for acute MI

Variable	MA	UA	RA	p-value
One-year				
All-cause mortality	21.3	21.0	21.0	0.96
Readmission (all-cause cardiac)	26.8	35.3	31.7	<0.0001
Readmission (acute MI, unstable angina, CHF)	19.8	25.3	21.5	<0.0001
Long-term				
All-cause mortality	32.0	31.6	32.3	0.88
Readmission (all-cause cardiac)	37.0	43.8	40.5	<0.0001
Readmission (acute MI, unstable angina, CHF)	29.2	34.5	30.5	0.0004

3.4 Discussion

We sought to determine the impact of a patient's place of residence on rates of cardiac catheterization and on long-term rates of all-cause mortality and readmission to hospital in Nova Scotia. Following adjustment for differences between patients in terms of age, sex, co-morbid illness and estimated income level, place of residence in areas remote from the single tertiary cardiac care centre in Nova Scotia emerged as being independently associated with lower rates of cardiac catheterization within the first six months following admission as well as higher long-term rates of readmission to hospital for any cardiac cause. No differences were noted regarding long-term rates of all-cause mortality.

Table 3.5: Multivariate predictors of long-term readmission to hospital for any cardiac cause in patients admitted for acute MI

Variable	**HR**	**95% CI**	**p-value**
Age			
> 70	0.88	(0.77, 0.99)	0.04
61 - 70	0.97	(0.85, 1.10)	0.62
51 - 60	0.94	(0.82, 1.07)	0.33
≤ 50	1.00	-	-
Female sex	0.94	(0.87, 1.02)	0.13
Smoking history	1.06	(0.98, 1.15)	0.15
Hypercholesterolemia	1.22	(1.13, 1.32)	<0.0001
Diabetes	1.21	(1.12, 1.31)	<0.0001
Hypertension	1.13	(1.05, 1.22)	0.001
Congestive heart failure	0.99	(0.88, 1.12)	0.93
Previous MI / unstable angina	1.27	(1.16, 1.38)	<0.0001
COPD / asthma	0.99	(0.91, 1.10)	0.99
Renal failure	0.97	(0.82, 1.16)	0.76
Cerebrovascular disease	0.98	(0.87, 1.10)	0.70
Prior CABG / PCI	1.14	(1.01, 1.28)	0.03
Income			
Lowest			
Second	1.04	(0.90, 1.19)	0.61
Middle	1.15	(1.00, 1.33)	0.05
Fourth	1.03	(0.89, 1.19)	0.71
Highest	1.08	(0.93, 1.26)	0.30
Geography			
RA	1.12	(1.01, 1.25)	0.04
UA	1.24	(1.11, 1.39)	0.0001
MA	1.00	-	-

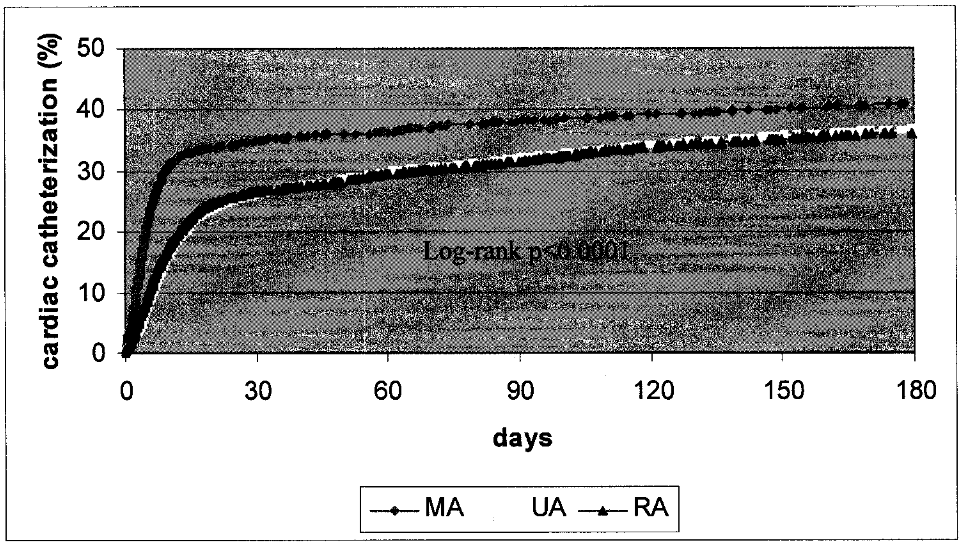

Figure 3.2: Cumulative rates of cardiac catheterization in the first six months following admission for acute MI stratified by place of residence

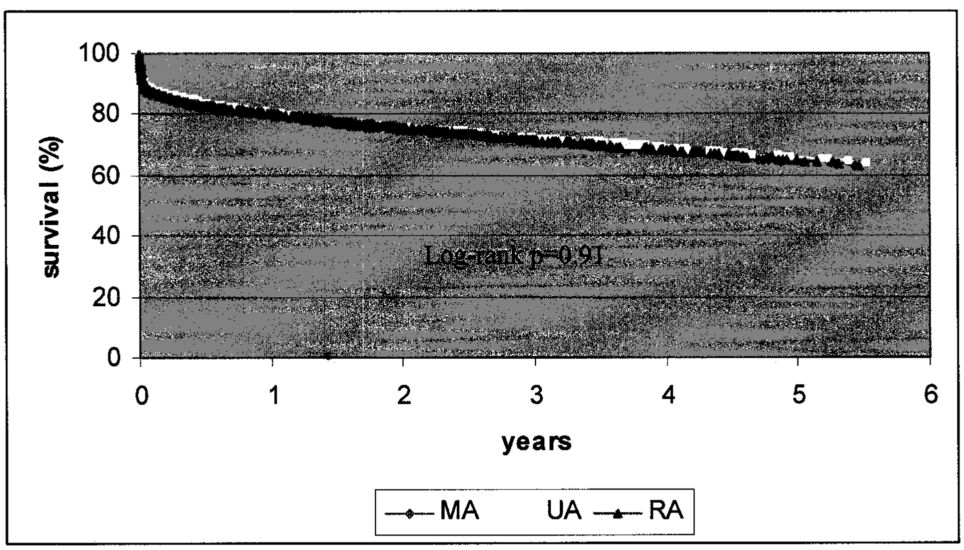

Figure 3.3: Kaplan Meier Survival curves with all-cause mortality stratified by place of residence as outcome of interest in patients admitted for acute MI

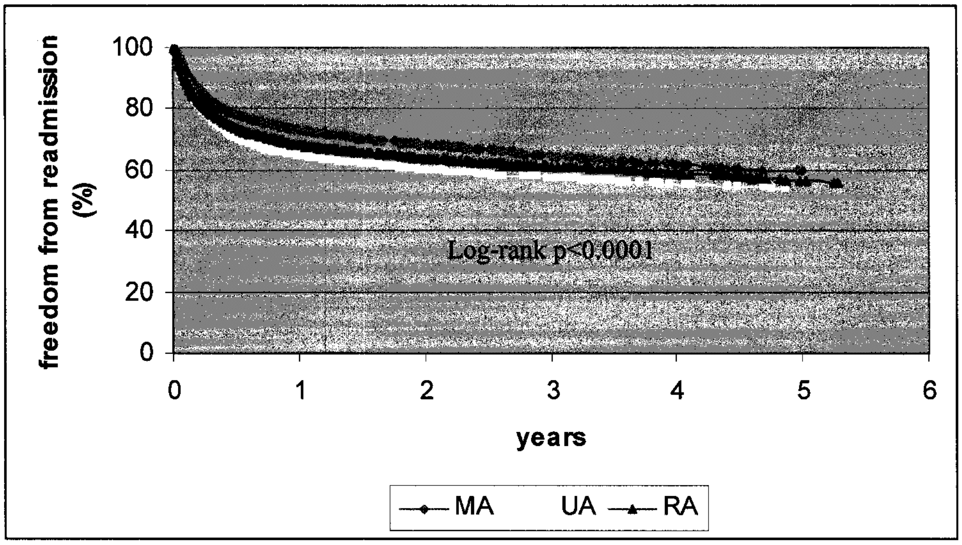

Figure 3.4: Kaplan Meier Survival curves with readmission to hospital for any cardiac cause stratified by place of residence as outcome of interest in patients admitted for acute MI

Our findings confirm findings of studies in other provincial jurisdictions across Canada with regard to regional variation in rates of cardiac catheterization following an acute MI(65-67, 69, 71, 72, 79, 143-147). However, we were unable to attribute such regional variation to differences in socioeconomic status, an association that has been demonstrated in earlier studies from Ontario and Quebec(67, 71). Rather, place of residence emerged as an independent predictor of rates of cardiac catheterization following an acute MI. This is similar to findings from the United States where decreased distance between the patient's residence and the nearest cardiac revascularization services was found to be predictive of increased rates of invasive cardiac care(154).

The relationship that we documented between residence in either UA or RA and reduced rates of and prolonged wait times for cardiac catheterization may reflect barriers in access to care that exist at the level of the health care provider. We have shown that patients in Nova Scotia who were admitted closest to or at the QE II Health Sciences Centre were more likely to be admitted under a cardiologist. Prior studies from the United States have shown that patients with an acute MI who were admitted under a cardiologist were more likely to undergo coronary angiography and subsequent coronary revascularization(155, 156). This appears to hold true in Nova Scotia where rates of cardiac catheterization were highest in areas where patients were more likely to be primarily cared for by a cardiologist. We hypothesized that the reduced rates of cardiac catheterization seen in patients from UA or RA would be associated with increased rates of non-invasive testing but found that this was not the case as patients with the highest rates of cardiac catheterization were also those with the highest rates of non-invasive testing.

Alternatively, patient-specific factors may have influenced whether or not a patient sought advanced cardiac care and ultimately underwent cardiac catheterization. A recent study by Alter *et al.* demonstrated that a patient's socioeconomic status as measured by self-reported income and education levels influenced access to cardiac services as well as his or her perception of the care received(143). It may be postulated that patients living in closer proximity to the tertiary cardiac care centre represented a group of people that were more motivated to seek out the highest level of care available to them, thus causing rates of cardiac catheterization to be higher in this group. Conversely, patients from more remote areas, in particular elderly patients, may have been less inclined to travel to the tertiary care center either because they are unwilling to undergo more aggressive treatment or because they are satisfied with the care available to them at their local hospital.

Following cardiac catheterization, rates of subsequent PCI or CABG and wait times from the point of catheterization to the point of revascularization did not differ by place of residence. This likely reflects the relatively uniform approach to revascularization employed by practitioners in Nova Scotia and the effectiveness of a peer-reviewed cardiovascular surgery conference system practiced at the QE II Health Sciences Centre where patients who are referred for surgery are impartially reviewed by a panel of cardiovascular specialists who determine surgical eligibility and priority based on such criteria as coronary anatomy, stress-test results and functional status, regardless of place of residence (23).

In this study, long-term survival was found to be similar across the three geographic groups. It has been repeatedly shown in both Canada and the United States that the impact of increased rates of cardiac catheterization on long-term survival is negligible(66, 69, 71, 72, 143, 154, 157, 158). However, randomized clinical trials have demonstrated reduced rates of symptom recurrence, readmission to hospital and, in some instances, rates of mortality, in patients admitted with an acute MI who were managed with an early invasive strategy as compared to those who were managed conservatively(43, 159, 160). Keeley *et al.*, in their meta-analysis of 23 randomized trials comparing the results of primary PCI with those of thrombolytic therapy in patients with ST-segment elevation acute MI, touted the benefits of primary PCI in reducing mortality and morbidity both in the short-term and in the long-term(161). It is possible that the lack of a mortality benefit in patients from MA despite their higher rates of cardiac catheterization reflects the absence of a comprehensive primary PCI program at the QEII Health Sciences Centre during the study period relative to other cardiac care centres in Canada(79).

Rates of readmission to hospital for any cardiac cause over time were significantly increased in patients living outside of MA, likely reflecting the reduced rates of and delays in access to cardiac catheterization experienced by affected patients. However, other factors may have played a pivotal role in determining whether or not a patient was readmitted to hospital. First, although use of evidence-based cardiovascular medications in Nova Scotia is rising and approaching reasonable levels for certain drug classes(162), we found significant variation in prescription rates of disease-modifying cardiovascular medications existed across the three geographic strata, which may, in turn, explain the differing readmission rates. Secondly, level of follow-up with either a specialist or a non-specialist after initial discharge from hospital may have varied considerably across geographic groupings and subsequently impacted on the patient's eventual need for readmission(163). Finally, the threshold for readmission to hospital, particularly for diagnoses other than acute coronary syndrome, may have been lower in peripheral, non-tertiary care centres where health care providers might have been less comfortable managing such conditions on an outpatient basis.

This study is the first to employ a province-wide, population-based disease-specific registry to examine the effect of clinical and non-clinical factors on access to invasive cardiac services and long-term outcomes following an acute MI. It provides valuable insights into the role that place of residence plays in determining the level of care that a patient with an acute MI receives and the potential deleterious effect that it may have on rates of readmission to hospital over time. However, this study is not without its limitations. First of all, individual-level data concerning socioeconomic status, including personal income, education and occupation level, were lacking, thereby necessitating the use of ecologic-level markers of socioeconomic status. While the use of ecologic-level measures of socioeconomic status in health outcomes research has previously been validated(151, 152), a number of more recently published studies have indicated that treatment of ecologic-level measures as patient-level factors may yield erroneous conclusions and that such measures should be treated as group-level or contextual-level variables rather than patient-level variables(67, 71, 164-166). Secondly, a registry, while more detailed than an administrative dataset, is still not fully comprehensive. One cannot therefore ensure that all potentially important confounding variables have been adjusted for and that the differences seen in long-term outcomes are the result of residual confounding.

3.5 Conclusion

In patients admitted with an acute MI in Nova Scotia, residence in either UA or RA was associated with diminished rates of cardiac catheterization, higher wait-times and increased long-term readmission rates after adjusting for differences between patients in terms of age, sex, co-morbid illness, and income level. Despite universal health coverage and a small geographic area, the high degree of centralization of tertiary cardiovascular services in Nova Scotia appears to be associated with significant disparities in access to invasive cardiovascular diagnostic and interventional treatment procedures according to location of residence. Importantly, those patients with the greater access barriers were those with the worst outcomes. Further studies are required to better understand the reasons underlying these apparent inequalities in the Canadian public health care system.

Chapter 4: Geography and Long-Term Outcomes Following Coronary Artery Bypass Grafting

4.1 Introduction

The roles of socioeconomic status (SES) and geography as independent determinants of adverse health outcomes have been well-established in patients with ischemic heart disease (IHD)(25, 62, 145, 167, 168). Studies have shown that following admission for an acute myocardial infarction (MI), individuals of lower SES or of a particular geographic place of residence are less likely to undergo cardiac catheterization, percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG)(55, 65, 66, 69, 71, 79, 143, 144, 146, 147, 154, 157, 169) and are more likely to experience increased morbidity(66, 69, 144, 169) and mortality(65, 75, 147, 169). Putative mechanisms for these observations include increased geographic distance between a patient's residence and the nearest cardiac revascularization facility(55, 154), lack of on-site cardiac catheterization services at the hospital of admission(144, 157) and prolonged exposure to cardiac risk factors among people of lower SES(25, 26, 28, 170). However, these explanations have focused to a large extent on the notion that SES and geography are correlates of diminished access to health care services and adverse health behaviour. Few studies have examined whether the negative impact of SES and geography persist beyond the risk incurred by traditional clinical risk factors alone in patients who have gained access to health care services and have subsequently undergone invasive cardiac procedures(21, 22).

The objective of this study was to determine the independent effect of SES and geography on long-term outcomes following CABG.

4.2 Methods

4.2.1 Study Population

All residents of Nova Scotia who underwent first-time, isolated CABG at the single provincial tertiary cardiac care centre between March 1, 1995 and June 30, 2002 were identified. From this group, those patients with complete data fields allowing for linkage with provincial administrative databases for long-term follow-up until December 31, 2002 were included in the final study population.

4.2.2 Data Sources

Data were obtained from the Maritime Heart Centre Cardiac Surgery Registry (MHCCSR) that prospectively collects detailed pre-, intra- and in-hospital post-operative clinical information on all patients undergoing cardiac surgery in Nova Scotia. Data from the MHCCSR were linked with the Nova Scotia Vital Statistics and Canadian Institute for Health Information (CIHI) provincial administrative databases to track long-term adverse events.

4.2.3 Variable Selection

Pre-operative variables of interest included age ($\geq$ 80, 70 – 79, < 70), sex, smoking history, diabetes, hypercholesterolemia, hypertension, renal insufficiency (pre-operative serum creatinine (Cr) of $\geq$ 176 μmol/L), peripheral and/or cerebrovascular disease, left ventricular ejection fraction or EF (EF < 40% vs. EF ≥ 40%), recent MI defined as the occurrence of an MI in the 3 weeks prior to surgery, urgency status (procedure performed within 24 hours from the point of referral vs. procedure performed at a time interval of greater than 24 hours from the point of referral), number of diseased vessels (left-main (LM) or triple-vessel disease vs. single- or double-vessel disease) and time from cardiac catheterization to surgery. Intra-operative variables of interest included whether the surgery was performed with or without cardiopulmonary bypass (on-pump vs. off-pump), whether or not the left internal mammary artery (LIMA) was used, number of distal anastomoses, cross clamp time and total bypass time. Long-term adverse outcomes of interest included all-cause mortality, repeat revascularization by either PCI or CABG and readmission to hospital for any cardiac cause as defined by the following codes from the ninth revision of the International Classification of Disease, Clinical Modification (ICD-9-CM): 410 (acute MI), 411 (unstable angina), 412 (remote MI), 413 (angina pectoris), 414 (other forms of chronic IHD), 426 (conduction disorders), 427 (cardiac dysrrhythmias) and 428 (heart failure).

4.2.4 Socioeconomic Information

We relied on 2001 Canadian census data to determine the median individual education and income level of the particular neighbourhood corresponding to a patient's geographic place of residence. This was done by linking a patient's postal code to a census dissemination area using the Postal Code Conversion File, a digital file published by Statistics Canada that provides a correspondence between the Canada Post's six-digit postal code and Statistics Canada's standard geographical areas for which census data and other statistics are produced(150). As a result, each patient was assigned a median education and income level as an estimate of their SES. Education was divided into two categories (less than or equal to Grade 12 and post-secondary including trade school, college and university), while income was separated into quintiles using median individual income values from across the province (all figures in Canadian dollars) (lowest, \$7,392 – \$14,844; second, \$14,865 – \$17,067; middle, \$17,097 – \$19,984; fourth, \$19,986 – \$24,617; highest, \$24,675 - \$53,946).

4.2.5 Geographic Information

Six-digit postal codes were used to determine the patient's geographic place of residence. Postal codes with '0' as the second digit were deemed rural areas (RA), while those with a second digit other than '0' were considered urban areas(153). Among neighbourhoods defined as urban areas, those located within or adjacent to the metropolitan area of Halifax, Nova Scotia were designated metropolitan areas (MA), and those located outside of Halifax were designated non-metropolitan urban areas (UA). Patients from MA lived closest to the single tertiary cardiac care centre, while patients living within UA were closest to regional hospitals and those living within RA were closest to community hospitals.

4.2.6 Statistical Analysis

Age- and sex-adjusted rates of CABG were calculated for each geographic grouping using the population distribution of Nova Scotia as per the 2001 Canadian census. Univariate comparisons between the three geographic groupings were carried out on the basis of pre-, intra- and post-operative variables using the chi-squared test for categorical variables and the two-sided t-test for continuous variables. Unadjusted Kaplan-Meier survival curves and fully-adjusted Cox proportional hazard models were generated to assess the effect of geographic place of residence on rates of long-term adverse events over time. The multivariate models were adjusted for differences between patients in terms of age, sex, co-morbid illness, coronary disease severity, surgical acuity and SES. Statistical significance was indicated by a p-value of less than 0.05 in all analyses. All statistical analyses were performed using the SAS statistical analyzing software package version 8.2 (SAS, Cary, North Carolina).

4.3 Results

Between March 1, 1995 and June 30, 2002, a total of 5181 residents of Nova Scotia underwent isolated, first-time CABG. Of these individuals, 5168 (99.7%) had records that could be linked to administrative databases with long-term follow-up until December 31, 2002. From the final study population, 1579 patients belonged to MA (age- and sex-adjusted CABG rate 91.6 / 100 000 persons / year), 1358 to UA (79.5 / 100 000 persons / year) and 2231 to RA (82.8 / 100 000 persons / year).

Table 4.1: Baseline and surgical characteristics of patients undergoing CABG in Nova Scotia by geographic place of residence

Variable	**MA n=1579**	**UA n=1358**	**RA n=2231**	**p-value**
Age (%)				0.39
≥ 80	6.4	6.3	6.5	
70 - 79	27.8	30.6	30.5	
< 70	65.8	63.1	63.0	
Female sex (%)	26.2	27.5	25.2	0.31
Smoking history (%)	68.4	71.2	69.9	0.25
Diabetes (%)	33.4	34.7	31.5	0.12
Hypercholesterolemia (%)	65.4	73.3	69.6	<0.0001
Hypertension (%)	59.9	61.9	58.7	0.17
Pre-op renal failure (%)	5.5	5.0	5.6	0.74
Peripheral/cerebral vascular disease (%)	22.9	23.1	23.2	0.98
Ejection fraction < 40% (%)	12.1	11.6	10.7	0.38
Recent MI (< 3 wks) (%)	13.9	10.6	10.7	0.003
Urgency (< 24h) (%)	16.6	15.4	15.2	0.46
LM / 3-vessel disease (%)	80.0	80.0	80.9	0.67
Income quintile (%)				<0.0001
Lowest	3.3	22.5	19.5	
Second	5.3	33.5	33.1	
Middle	14.8	26.7	29.5	
Fourth	40.0	14.4	12.6	
Highest	36.3	2.6	4.2	
Education (%)				<0.0001
Less than Grade 12	4.7	31.4	42.4	
Post-secondary	95.3	68.6	57.6	
Time from cardiac catheterization to surgery (all cases) (days)	46.1	44.1	46.4	0.49
Time from cardiac catheterization to surgery (elective cases) (days)	52.1	49.8	51.8	0.56
Off-pump (%)	6.1	4.4	4.9	0.09
Left internal mammary artery (%)	90.8	90.6	90.0	0.12
No. distal anastomoses (mean)	3.2	3.1	3.1	0.09
Cross clamp time (min) (mean)	68.3	68.2	67.6	0.71
Total bypass time (min) (mean)	105.2	105.5	105.5	0.95

Comparisons between the three geographic strata on the basis of pre- and intra-operative clinical variables revealed few significant differences (Table 4.1). Although rates of recent MI were higher in patients from MA, there was a lack of any difference across the three groupings with regard to clinical urgency at time of presentation or waiting times from cardiac catheterization to surgery. However, comparisons across determinants of SES revealed that patients from both UA and RA had significantly lower neighbourhood incomes and lower rates of post-secondary education than did patients from MA.

Median length of follow-up was 45 months. While rates of repeat revascularization and long-term all-cause mortality did not differ between geographic groupings, patients from UA and RA experienced higher rates of re-hospitalization than patients from MA (Table 4.2), a difference which increased over time (Figure 4.1).

Unadjusted, geographic place of residence emerged as a significant predictor of re-hospitalization for any cardiac cause over time (UA: HR 1.32, 95% CI (1.14, 1.53); RA: HR 1.18, 95% CI (1.03, 1.35)). After adjustment for differences between patients in terms of clinical and socioeconomic factors, residence in either UA or RA remained a significant independent predictor of readmission to hospital for any cardiac cause following CABG (Table 4.3).

Table 4.2: Long-term outcomes in patients undergoing CABG in Nova Scotia by geographic place of residence

Outcome	MA (%)	UA (%)	RA (%)	p-value
Repeat revascularization (PCI / CABG)	3.2	3.5	3.1	0.79
All-cause mortality	10.4	11.7	12.3	0.18
Readmission (any cardiac cause)	21.5	25.6	24.7	0.02

Table 4.3: Multivariate Cox proportional-hazards regression analysis of factors associated with readmission to hospital over time for any cardiac cause in patients undergoing CABG

Variable	HR	95% CI	p-value
Age			
>= 80	1.45	(1.16, 1.81)	0.0009
70 - 79	1.15	(1.02, 1.31)	0.03
< 70	1.00	-	-
Female sex	1.26	(1.11, 1.43)	0.0003
Smoking history	1.02	(0.90, 1.16)	0.78
Diabetes	1.44	(1.28, 1.62)	<0.0001
Hypercholesterolemia	0.94	(0.84, 1.06)	0.34
Hypertension	1.14	(1.01, 1.29)	0.03
Pre-op renal failure	1.59	(1.29, 1.96)	<0.0001
Peripheral/cerebral vascular disease	1.39	(1.23, 1.58)	<0.0001
EF < 40%	1.67	(1.43, 1.96)	<0.0001
Recent MI (< 3 wks)	1.02	(0.84, 1.22)	0.87
Urgency (< 24h)	1.43	(1.23, 1.66)	<0.0001
LM / 3-vessel disease	0.82	(0.71, 0.94)	0.005
Income quintile			
Lowest	1.18	(0.91, 1.53)	0.22
Second	1.25	(0.99, 1.59)	0.06
Middle	1.14	(0.91, 1.43)	0.24
Fourth	1.10	(0.87, 1.35)	0.40
Highest	1.00	-	-
Education			
Less than Grade 12	0.88	(0.76, 1.02)	0.09
Post-secondary	1.00	-	-
Geographic group			
RA	1.19	(1.01, 1.40)	0.04
UA	1.30	(1.09, 1.54)	0.004
MA	1.00	-	-

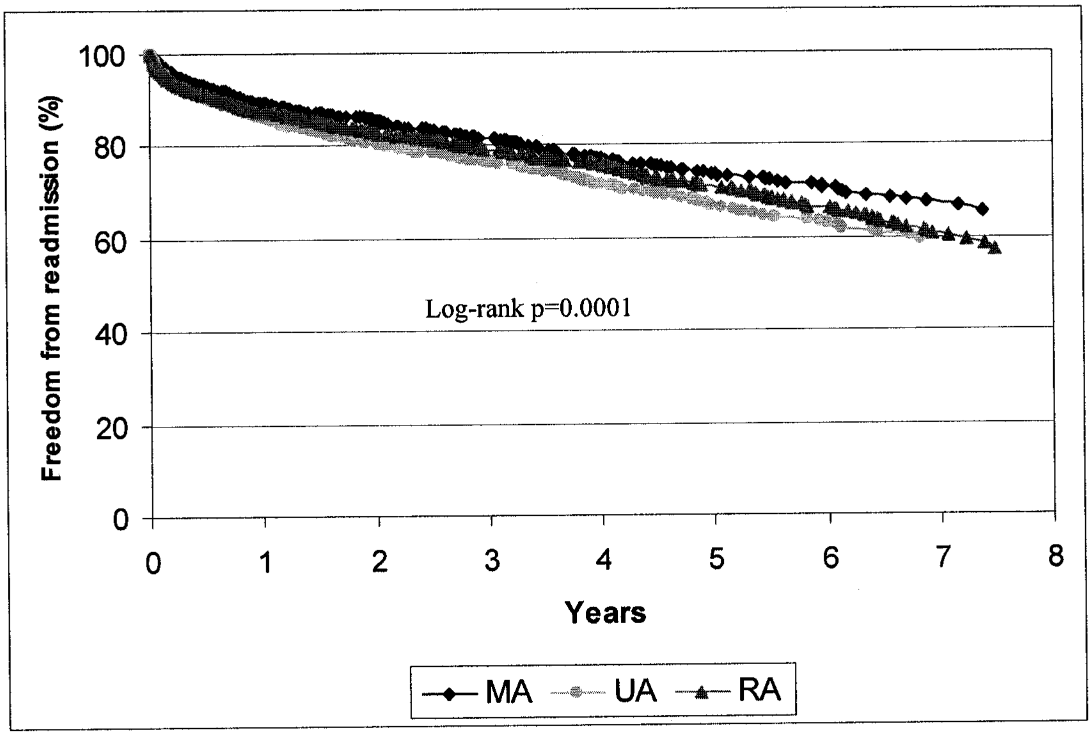

Figure 4.1: Unadjusted Kaplan Meier survival curves with readmission to hospital for any cardiac cause stratified by geographic place of residence as long-term outcome of interest in patients undergoing CABG

4.4 Discussion

In this study, we sought to determine the effect of SES and geography on long-term outcomes after CABG in Nova Scotia, Canada. The results revealed that following adjustment for differences between patients in terms of age, sex, co-morbid illness and SES, geography as defined by the patient's place of residence emerged as an independent predictor of higher rates of readmission to hospital for any cardiac cause over time following CABG. No differences were noted between the geographical groupings regarding long-term rates of repeat revascularization and all-cause mortality.

To date, few studies have assessed the impact of geography and SES on outcomes following CABG beyond traditional clinical factors alone. Boscarino *et al.* examined the effect of community SES and race on survival following CABG in Louisville, Kentucky and found that patients from counties with the lowest housing values had a significantly increased risk of mortality at 36 months after CABG(21). Similarly, Ancona *et al.* assessed the effect of SES on access to and 30-day mortality following CABG in Rome, Italy and found that individuals from the most socially disadvantaged SES stratum experienced the lowest rates of CABG and the highest 30-day mortality rates(22).

Unlike the geographic settings in which the studies by Boscarino *et al.* and Ancona *et al.* were conducted, the province of Nova Scotia is mandated by the Canada Health Act to provide universal health care coverage defined as reasonable access to quality health care for all of its residents regardless of sex, race, SES or geography(61). Hence, the absence of a mortality differential across either geographic or socioeconomic strata as found previously by Boscarino *et al.* and Ancona *et al.* may be seen as a success of the Canadian universal-coverage health care system wherein patients regardless of their geographic place of residence or SES enjoy similar long-term survival following CABG. However, differences in long-term rates of readmission to hospital may perhaps be explained as a failure on the part of the Canadian health care system to completely eliminate inequalities related to access to and quality of care. The lower rates of re-hospitalization seen among patients from MA could be explained, for instance, by the close proximity of these individuals to the sole tertiary cardiac care centre and the greater density of cardiac care services and specialists in this area. The increased availability of such resources may have resulted in an increased level of expert follow-up which would have allowed for better prevention of coronary disease progression and earlier symptom detection. Rutten et al demonstrated the increased the increased propensity for general practitioners to use less additional investigations and prescribe less potentially beneficial medication in patients with heart failure as compared to cardiologists(171, 172).

On the other hand, the higher rates of re-hospitalization seen among patients from UA and RA may have been due to provider-related factors such as variations in practice patterns whereby physicians in UA and RA possessed lower thresholds for readmission. Previous studies have demonstrated the differences that may exist in physicians' hospitalization practices(173, 174) and the extent to which many of these hospitalizations may be preventable with a better understanding of local admitting practice patterns(175) and by optimized care in the ambulatory setting(176). The higher rates of re-hospitalization may have also been the result of patient-specific factors, including inadequate reduction of modifiable risk factors, medication non-compliance, lack of regular physician visits and unwillingness on the part of patients from these regions to seek medical attention until symptoms had significantly worsened. Harju *et al.* illustrated that although attitudes toward seeking medical were similar among rural and urban residents, how they affected health-oriented behaviour differed considerably between the two groups(177). Finally, while the time from cardiac catheterization to surgery did not differ across the three geographic groupings in this study, data were lacking regarding the time from initial onset of symptoms to cardiac catheterization. Any delays in access to care occurring early in the management of these patients may have accounted for some of the inter-regional variability in long-term outcomes following CABG.

This study has certain limitations. First of all, where this study was a retrospective analysis that used data from a combination of clinical and administrative databases, the authors were limited to risk-adjusting with only those clinical and socio-demographic variables that were measured. Unmeasured confounders may have, to some extent, accounted for the long-term differences seen between patients from different geographic groupings. Propensity score analysis has been advocated to minimize such confounding(178-180). A recent review of the literature, however, demonstrated the lack of any difference between results obtained using propensity score methods and those using traditional regression modeling techniques(181) As a result, propensity score methods were not employed in this study. Secondly, there was a lack of detailed information available on the long-term post-operative management of patients having undergone CABG. Such data, including differences in medication use and consistency of clinical follow-up may have served to explain the increased rates of readmission to hospital over time. Finally, the lack of an effect of SES on long-term outcomes should be interpreted with caution given the often inextricable relationship between SES and geography. In spite of efforts to adjust for differences between geographic groups in terms of neighbourhood income and education, it may not be entirely accurate to state that differences in SES had been completely adjusted for and to assign the burden of increased rates of readmission on geography alone; rather, SES must continue to be thought of as a potential co-explanatory variable requiring further study with detailed individual-level and neighbourhood-level SES data, data pertaining to socioeconomic trajectories and accumulation of socioeconomic exposure over lifetimes(25, 26, 28) and advanced statistical modeling techniques (hierarchical or multilevel modeling)(165, 166).

4.5 Conclusion

No differences were noted in long-term rates of repeat revascularization and all-cause mortality following CABG across geographic groupings. However, long-term rates of readmission following CABG were found to be higher among patients from UA and RA as compared to patients from MA, even following adjustment for differences in clinical factors such as age, sex and co-morbid illness. These results highlight the importance of considering traditional clinical factors as well as non-traditional socioeconomic and geographic factors when estimating risk of long-term adverse events in patients undergoing CABG and when formulating interventions by which to reduce such risk.

Chapter 5: Socioeconomic and Geographic Determinants of Readmission: A Population-Based, Multi-Level Analysis

5.1 Introduction

The significant role of socioeconomic status (SES) and geography as independent determinants of adverse health outcomes have increasingly been established in patients admitted with cardiovascular disease (CVD), including those admitted in jurisdictions with universal health care coverage(25, 62, 145, 167, 168). Following admission for an acute myocardial infarction (MI), individuals of lower SES or of a particular geographic place of residence are less likely to undergo cardiac catheterization(65, 66, 69, 143, 144) and are more likely to experience increased morbidity(66, 69, 144) and mortality(65). The results of these studies have provided clinicians and health policy makers with a better understanding of these factors and have helped frame interventions targeted at eliminating gaps in care that existed and that could not be eliminated by addressing clinical risk factors alone.

Earlier studies of the association between SES, geography and CVD, area-level measures of SES were often used as proxies for individual-level SES as individual-level SES data were lacking. The success of this methodology has been somewhat varied(151, 152, 182-186). More recently, researchers have investigated the multi-level or hierarchical nature of socioeconomic and geographic factors in relation to CVD incidence(30, 31, 165, 166, 187) and outcomes(67, 71, 164, 169). The hierarchical approach enables one to differentiate between individual-level and area-level effects and to appreciate the interaction between these multi-level variables(165, 166), thus encouraging the development of health care policies that are not only person-centred but environment-centred as well(31).

To date, while many studies have instituted multi-level or hierarchical modeling in assessing outcomes in patients admitted with CVD(67, 71, 164, 169), few have actually had access to both individual-level and area-level data concerning socioeconomic or geographic characteristics. As a result, the majority of studies have relied upon area-level characteristics exclusively to form conclusions regarding the importance of socioeconomic and geographic factors on CVD outcomes.

The objective of this study was to examine the combined effect of individual-level and area-level socioeconomic and geographic factors on long-term rates of readmission in patients admitted with CVD in Nova Scotia, Canada.

5.2 Methods

5.2.1 Data Sources

Data were obtained from the Improving Cardiovascular Outcomes in Nova Scotia (ICONS) database, a population-based, province-wide clinical registry that from October 1, 1997 until the present has captured information on all hospitalizations across Nova Scotia for cardiovascular disease (CVD), including acute MI, unstable angina, congestive heart failure (CHF), atrial fibrillation and other related diagnoses (stable angina, chronic ischemic heart disease and non-specific chest pain)(148, 149). In addition to possessing detailed data regarding patient demographic characteristics and co-morbid illness for each hospitalization, the ICONS database tracked discharge drug prescriptions, procedure use (cardiac catheterization, percutaneous coronary intervention, coronary artery bypass grafting and heart valve surgery), long-term all-cause mortality and long-term readmission to hospital for any of the aforementioned cardiac causes.

5.2.2 Study Population

All residents of Nova Scotia admitted between October 15, 1997 and December 31, 2002 with a diagnosis of CVD and with long-term follow-up until December 31, 2003 were identified. During this time, a subset of patients completed an enrolment survey which requested information regarding socioeconomic status including household income. It is this subset of patients that formed the basis for the final study population.

5.2.3 Variable Definitions

Individual-level clinical variables of interest included diagnosis on admission (acute MI, unstable angina, CHF, atrial fibrillation, other), age (≥ 70, 60 – 69, 50 – 59, < 50), sex, history of smoking, hyperlipidemia, diabetes and hypertension and history of CHF, acute MI or unstable angina. Missing values for clinical variables were coded for explicitly and included in the analysis; however, their unadjusted and adjusted odds ratios were not reported.

Self-reported or individual-level socioeconomic data were available through the ICONS database as part of the voluntary enrolment survey completed by the patients. Individual-level income was reported by the patient in the form of annual gross household income and was separated into five categories (expressed in Canadian dollars): ≤ $19 999, $20 000 - $29 999, $30 000 - $39 999, $40 000 - $49 999 and ≥ $50 000. Meanwhile, individual-level education was divided into two categories: less than or equal to Grade 12 and post-secondary (technical or trade school, community college or university). In order to obtain area-level socioeconomic data, we relied on 2001 Canadian census data to determine the median household income level and the median neighbourhood education level of the patient's geographic place of residence. This was done by linking the patient's postal code to census dissemination area(s) using the Postal Code Conversion File(150). Area-level income was separated into three categories (as expressed in Canadian dollars): ≤ $29 999, $30 000 - $49 999 and ≥ $50 000, and area-level education was divided into two categories: less than or equal to Grade 12 and post-secondary (technical or trade school, community college or university). Patients who did not provide individual-level income or education data or for whom area-level income or education data was not reported (the consequence of area-level socioeconomic data being suppressed by Statistics Canada for small-area neighbourhoods) were excluded from the final analysis.

Three separate area-level geographic indicators were used: 1) distance from the index hospital of admission to the single tertiary cardiac care centre in Nova Scotia, 2) rural versus urban designation and 3) district health authority (DHA). First of all, straight line distance from the patient's index hospital of admission to the sole tertiary cardiac care centre in Nova Scotia, the Queen Elizabeth II (QE II) Health Sciences Centre, was calculated and then grouped into tertiles (0 - 70 km, 71 - 163 km and >163 km).

Secondly, rural versus urban designation was determined based on the patient's six-digit postal code. Postal codes with '0' as the second digit, indicative of areas with a population of less than 1 000, were deemed rural areas (RA), while those with a second digit other than '0' were considered urban areas(153). Finally, the province of Nova Scotia is divided into nine regional DHAs (Figure 5.1). The provincial ministry of health delegates to each DHA the responsibility of governing, planning, managing, delivering, monitoring and evaluating health services within their region(188). The QE II Health Sciences Centre is located in DHA 9 which serves as the referent DHA against which all other DHAs were compared.

The primary outcome of interest was long-term readmission to hospital for any cardiac cause. Cardiac readmission was chosen over all-cause mortality because of the increasing evidence supporting an association between socioeconomic status, geography and increased rates of readmission in patients with CVD(69, 144). Furthermore, readmission to hospital indicates a significant failure to effectively manage a disease process and / or an inability to maintain a patient to be adequately functional in the community. Resorting to repeat acute care admissions imposes burdens on both the health care system as well as on the affected individuals and the communities in which they reside.

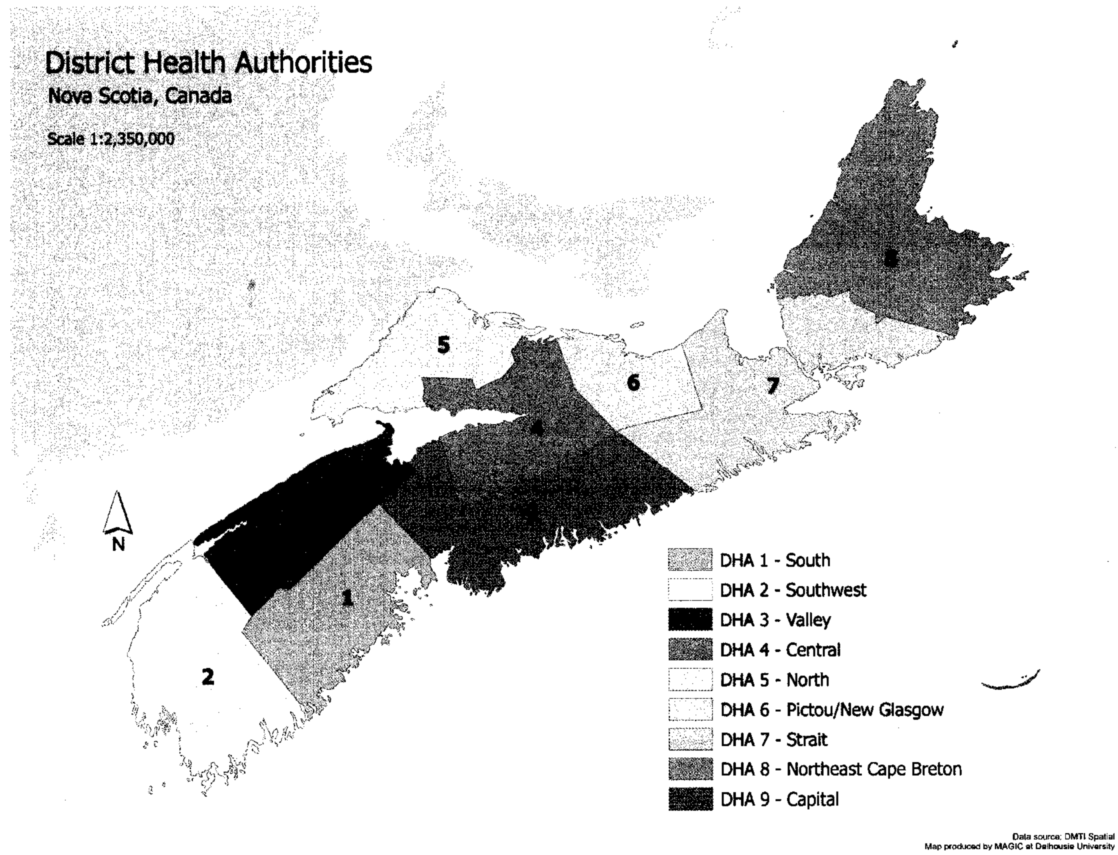

Figure 5.1: District health authorities (DHA) in the province of Nova Scotia

5.2.4 Statistical Approaches

The combined effect of individual-level and area-level factors on long-term rates of readmission in patients admitted with CVD was calculated using hierarchical logistic regression modelling techniques. Hierarchical logistic regression modelling considers both individual-level and area-level characteristics in explaining the outcome of interest(165, 166). It first fits a logistic regression model using individual-level variables within each geographic unit to predict the outcome of interest. In this study, the geographic unit of interest was defined by the patient's postal code. Where the intercept and slope coefficients are expected to vary across postal code regions, area-level characteristics are used to explain this across-area variation. The resulting hierarchical or multi-level model displays the risk-adjusted effect of individual-level and area-level characteristics on the outcome of interest.

In this study, we first calculated the unadjusted effects of individual-level and area-level factors on long-term rates of readmission. We then calculated the effects of individual-level and area-level socioeconomic and geographic factors on rates of re-hospitalization following adjustment for age, sex, admission diagnosis and clinical comorbidities. Finally, two parsimonious, fully-adjusted hierarchical models were constructed illustrating the effects of individual-level and area-level characteristics on the outcome of interest. In the first model, distance from the index hospital of admission to the QE II Health Sciences Centre and rural residence were included as the only area-level geographic variables. In the second model, DHA and rural residence were included as the only area-level geographic variables. Distance from the QE II Health Sciences Centre provided a sense of health care outcomes in terms of the geographic relationship between the index hospital of admission and the sole tertiary cardiac care centre in the province, while results associated with DHA reflected the success or failure of each of the nine regional governing bodies in providing health care to its respective constituents. The independent value of each of these variables supported the creation of two separate models. Cross-level interaction terms were assessed for each model and included where significant.

All statistical analyses were performed using the hierarchical modelling program HLM version 5.01.

5.3 Results

Between October 1, 1997 and December 31, 2002, a total of 31,210 patients were admitted across Nova Scotia with a diagnosis of CVD of whom 6451 (20.7%) had completed an enrolment survey requesting information regarding socioeconomic status. After excluding individuals with missing self-reported or neighbourhood income data, a total of 5016 (16.1%) formed the final study population Of these, 1373 were admitted with acute MI, 1261 with unstable angina, 543 with CHF, 380 with atrial fibrillation and 1459 with other related diagnoses.

An admission diagnosis of unstable angina or CHF, age ≥ 70 years, male sex, history of hyperlipidemia, a history of diabetes and a history of acute MI, unstable angina or CHF were associated with increased long-term rates of readmission (Table 5.1). Increased individual-level and area-level income levels were predictive of lower long-term rates of readmission as were higher levels of individual-level and area-level education; however, increased distance from the QE II Health Sciences Centre, residence in a rural area and residence in particular DHAs were associated with higher long-term rates of readmission (Table 5.1). The effect of individual-level socioeconomic factors and area-level socioeconomic and geographic factors on rates of re-hospitalization persisted following adjustment for age, sex, admission diagnosis and clinical comorbidities (Table 5.2), emphasizing the importance of socioeconomic and geographic factors above and beyond clinical factors when forecasting long-term outcomes in patients with CVD.

Two parsimonious, fully-adjusted hierarchical models, each employing a different combination of area-level geographic variables, highlighted the combined effect of individual-level and area-level characteristics on long-term rates of readmission (Table 5.3). The first model demonstrated the risk-adjusted predictive value of individual-level income, residence in a rural area and increased distance from the index hospital of admission to the QE II Health Sciences Centre in determining long-term rates of readmission, while the second model demonstrated the risk-adjusted predictive value of individual-level income, residence in a rural area and DHA in determining long-term rates of readmission.

5.4 Discussion

In this study, we examined the combined effects of individual-level and area-level socioeconomic and geographic factors on long-term rates of readmission in patients admitted with CVD in Nova Scotia, Canada. The results of this study revealed that following adjustment for differences in admission diagnosis, age, sex and co-morbid illness, lower individual-level income, residence in a rural area and geographic location emerged as independent predictors of higher rates of readmission to hospital for any cardiac cause over time. Of note, area-level income failed to predict readmission rates.

Table 5.1: Unadjusted odds ratios for clinical, socioeconomic and geographic factors in patients admitted with CVD

Variable	Readmission (%)	OR	95% CI
Diagnosis on admission			
Atrial fibrillation	60.4	0.89	(0.71, 1.10)
Acute myocardial infarction	62.9	1.05	(0.90, 1.23)
Unstable angina	51.8	1.26	(1.08, 1.47)
Congestive heart failure	56.2	1.40	(1.14, 1.72)
Other	54.8	1.00	-
Age			
≥ 70	61.3	1.30	(1.07, 1.57)
60 – 69	56.0	1.05	(0.86, 1.27)
50 – 59	54.6	0.97	(0.80, 1.18)
< 50	55.1	1.00	-
Sex			
Female	31.1	0.88	(0.78, 0.99)
Male	58.2	1.00	-
Smoking			
Current	57.1	1.03	(0.89, 1.21)
Past	57.3	1.04	(0.91, 1.19)
Never	56.2	1.00	-
Hyperlipidemia			
Yes	56.5	1.23	(1.05, 1.44)
No	51.2	1.00	-
Diabetes			
Yes	61.3	1.35	(1.18, 1.53)
No	53.9	1.00	-
Hypertension			
Yes	57.0	1.12	(0.99, 1.26)
No	54.5	1.00	-
History CHF/acute MI/UA			
Yes	61.9	1.38	(1.23, 1.55)
No	54.1	1.00	-
Individual-level income			
≤ $19 999	61.1	1.00	-
$20 000 - $29 999	59.6	0.94	(0.81, 1.09)
$30 000 - $39 999	56.6	0.83	(0.70, 0.99)
$40 000 - $49 999	53.5	0.74	(0.60, 0.91)
≥ $50 000	48.8	0.61	(0.52, 0.72)

(continued)

Variable	Readmission (%)	OR	95% CI
Area-level income			
≤ $29 999	58.0	1.00	-
$30 000 - $49 999	58.8	1.02	(0.88, 1.18)
≥ $50 000	50.4	0.74	(0.61, 0.89)
Individual-level education			
≤ Grade 12	59.6	1.34	(1.19, 1.52)
Post-secondary	52.2	1.00	-
Area-level education			
≤ Grade 12	59.7	1.18	(1.03, 1.34)
Post-secondary	56.2	1.00	-
District Health Authority			
DHA 1	60.0	1.46	(1.16, 1.84)
DHA 2	63.5	1.58	(1.22, 2.06)
DHA 3	64.6	1.73	(1.36, 2.21)
DHA 4	60.9	1.29	(0.98, 1.69)
DHA 5	59.6	1.52	(1.10, 2.10)
DHA 6	57.2	1.16	(0.91, 1.48)
DHA 7	57.4	1.17	(0.90, 1.53)
DHA 8	64.6	1.63	(1.36, 1.94)
DHA 9	52.1	1.00	-
Distance			
> 163km	62.4	1.51	(1.32, 1.74)
70 - 163km	60.7	1.39	(1.20, 1.61)
0 - 70km	52.0	1.00	-
Rural vs. Urban			
Rural	60.5	1.26	(1.12, 1.43)
Urban	54.8	1.00	-

Table 5.2: Odds ratios for individual-level and area-level socioeconomic and geographic factors in patients admitted with CVD, adjusted for age, sex and clinical characteristics

Variable	**OR**	**95% CI**
Individual-level income		
≤ $19 999	1.00	-
$20 000 - $29 999	0.94	(0.80, 1.09)
$30 000 - $39 999	0.85	(0.71, 1.02)
$40 000 - $49 999	0.78	(0.63, 0.97)
≥ $50 000	0.64	(0.54, 0.77)
Area-level income		
≤ $29 999	1.00	-
$30 000 - $49 999	1.05	(0.90, 1.22)
≥ $50 000	0.80	(0.66, 0.97)
Individual-level education		
≤ Grade 12	1.27	(1.12, 1.45)
Post-secondary	1.00	-
Area-level education		
≤ Grade 12	1.14	(1.00, 1.31)
Post-secondary	1.00	-
District Health Authority		
DHA 1	1.37	(1.08, 1.74)
DHA 2	1.55	(1.18, 2.03)
DHA 3	1.60	(1.25, 2.03)
DHA 4	1.18	(0.90, 1.55)
DHA 5	1.40	(1.01, 1.94)
DHA 6	1.09	(0.84, 1.40)
DHA 7	1.15	(0.87, 1.52)
DHA 8	1.52	(1.26, 1.82)
DHA 9	1.00	-
Distance		
> 163km	1.43	(1.24, 1.66)
70 - 163km	1.29	(1.11, 1.50)
0 - 70km	1.00	-
Rural vs. Urban		
Rural	1.23	(1.09, 1.39)
Urban	1.00	-

Table 5.3: Fully-adjusted, parsimonious hierarchical logistic regression model for patients admitted with CVD (odds ratios for age, sex and clinical characteristics not presented)

Variable	**OR**	**95% CI**
Individual-level income		
≤ $19 999	1.00	-
$20 000 - $29 999	0.95	(0.81, 1.11)
$30 000 - $39 999	0.87	(0.73, 1.04)
$40 000 - $49 999	0.81	(0.65, 1.01)
≥ $50 000	0.69	(0.57, 0.82)
Rural vs. Urban		
Rural	1.15	(1.01, 1.30)
Urban	1.00	-
Distance		
> 163km	1.36	(1.18, 1.58)
70 - 163km	1.21	(1.04, 1.42)
0 - 70km	1.00	-
Variable	**OR**	**95% CI**
Individual-level income		
≤ $19 999	1.00	-
$20 000 - $29 999	0.95	(0.81, 1.11)
$30 000 - $39 999	0.87	(0.72, 1.04)
$40 000 - $49 999	0.81	(0.65, 1.01)
≥ $50 000	0.68	(0.57, 0.82)
Rural vs. Urban		
Rural	1.17	(1.02, 1.34)
Urban	1.00	-
District Health Authority		
DHA 1	1.30	(1.02, 1.65)
DHA 2	1.38	(1.06, 1.80)
DHA 3	1.48	(1.15, 1.90)
DHA 4	1.14	(0.86, 1.49)
DHA 5	1.27	(0.90, 1.80)
DHA 6	1.00	(0.79, 1.26)
DHA 7	1.05	(0.79, 1.39)
DHA 8	1.50	(1.25, 1.81)
DHA 9	1.00	-

Diez Roux *et al.* have previously demonstrated the combined effects of individual-level and area-level socioeconomic and geographic characteristics on the incidence of coronary heart disease(31, 187) and the prevalence of associated risk factors(30) in the United States. More recently, a growing number of studies from Canada have adopted hierarchical logistic regression modeling in an attempt to explain the effect of SES and geography on rates of cardiac catheterization and overall health outcomes in patients admitted with an acute MI(67, 71, 164, 169). These studies have helped promote an appreciation for the hierarchical structure of socioeconomic and geographic data and the need for advanced statistical methodologies to adequately assess the impact of such factors on health outcomes(169). However, unlike the studies by Diez Roux *et al.*, they lacked individual-level socioeconomic data and thus relied exclusively on area-level data to form their conclusions. The only study that has, to date, employed both individual-level and area-level socioeconomic data was published by Southern *et al.* and demonstrated the combined importance of self-reported household income and area-based measures of household income in predicting survival and health-related quality of life in a cardiac disease cohort(189). However, these investigations did not adjust for differences between patients in terms of clinical variables and did not consider geographic factors in their analysis.

This study offers, to our knowledge, among the first appraisals of both individual-level and area-level socioeconomic and geographic factors in determining long-term outcomes in patients admitted with CVD. The emergence of individual-level income, rural vs. urban status and geographic location as determinants of long-term outcomes in this study emphasizes the importance of considering both individual-level and area-level factors when developing health policy initiatives geared at minimizing regional and patient-to-patient discrepancies in cardiovascular outcomes. For instance, improved follow-up of patients in geographic areas remote from the QE II Health Sciences Centre, the establishment of rotating clinics and permanent health care facilities in under-served rural regions and mechanisms to enhance cross-provincial access to the single tertiary care centre are examples of whereby geographic variation in rates of readmission may be reduced. On the other hand, promoting improved cardiovascular-related risk-factor behaviour and medication compliance among patients of lower individual SES regardless of geographic place of residence may serve to lessen variation in outcomes at the patient level. Ultimately, further study into the various individual-level and area-level characteristics, including differences in physician practice patterns and consumer willingness to seek and receive care, is needed in order to completely understand the above-seen association.

This study has certain limitations. First, there was a relatively low rate of enrolment survey completion among patients included in the ICONS database. This may be explained by the voluntary nature of the survey and by the fact that not every patient was approached to complete the survey. To the extent that patients completing the survey may have differed from those that did not, especially on the basis of individual-level socioeconomic factors, a selection bias could have been introduced. Ideally, it would have been useful to obtain individual-level socioeconomic data for all patients admitted across Nova Scotia with CVD; however, the purpose of this study was not to present definitive odds ratios regarding the impact of individual-level and area-level factors on long-term outcomes but rather to put forth a line of reasoning that underscores the value of including both levels of variables in future studies attempting to explain variation in outcomes by SES and geography. Secondly, little is known regarding the validity of self-reported income and education. There are a number of reasons why someone may misrepresent his or her true socioeconomic status, even in the setting of a confidential survey. For instance, individuals may have a tendency to under-report income(190) for fear of tax-related problems, particularly if they are self-employed. Furthermore, individuals may over-estimate their level of education(191) for the purposes of appearing socially desirable. However, it is not expected that such response bias would differ systematically from the response bias introduced when income and education data is collected by Statistics Canada at the neighbourhood level. Finally, absolute income may be misrepresentative of the actual or "effective" income that an individual may have to spend. For example, an individual living in a rural area may have more disposable income because of a lower cost of living than someone with the same income who lives in an urban area with a higher associated cost of living. This difference was not accounted for in our analysis.

5.5 Conclusion

Studies have previously explored the effect of area-level and individual-level socioeconomic and geographic factors on the prevalence of CVD and associated risk factors. However, few have investigated their combined impact on outcomes in individuals with CVD. In this study, we found that following adjustment for differences in individual-level and area-level factors, lower individual-level income, residence in a rural area and geographic location emerged as independent predictors of higher rates of readmission. These findings emphasize the importance of considering both area-level and individual-level factors when assessing the influence of socioeconomic status and geography on outcomes in patients with CVD and informing public policy.

Chapter 6: Conclusion

6.1 Synopsis

There exists a significant knowledge gap in the published literature regarding the effect of sex, socioeconomic status (SES) and geography on access to cardiac care and overall outcomes in patients with cardiovascular disease in Nova Scotia. The findings presented in this thesis serve to fill a portion of this void, providing a greater understanding of this complex relationship through the use of rich observational and administrative data and traditional as well as non-traditional statistical methodologies.

Chapter 2 highlighted the sex differences that exist in patients undergoing coronary artery bypass grafting (CABG). Women presented for surgery with more co-morbid disease and advanced symptoms. But even after adjusting for these baseline differences, female sex emerged as an independent predictor long-term mortality and/or cardiac readmission. Chapter 3 addressed the issue of SES and place of residence and their effect on access to cardiac catheterization and eventual long-term outcomes in patients admitted to hospital with an acute myocardial infarction (MI) in Nova Scotia. This study revealed that following adjustment for differences between patients in terms of age, sex, co-morbid illness and estimated income level, residence in areas remote from the single tertiary cardiac care centre in Nova Scotia independently predicted lower rates of cardiac catheterization within the first six months following admission as well as higher long-term rates of readmission to hospital for any cardiac cause. SES, as defined by income and education level, did not emerge as an independent predictor, highlighting the pre-eminent influence of geography on cardiac resource utilization over that of SES. This theme re-emerged in Chapter 4 where the association between SES, geography and long-term outcomes in patients undergoing CABG was explored. Following adjustment for differences between patients in terms of age, sex, co-morbid illness and SES, place of residence was found to be an independent predictor of higher rates of readmission to hospital for any cardiac cause over time following CABG. No differences were noted between the geographical groupings regarding long-term rates of repeat revascularization and all-cause mortality. Finally, Chapter 5 employed detailed individual-level and area-level indicators of SES and geography in conjunction with hierarchical logistic regression modeling to better define the relationship between SES, geography and cardiovascular outcomes. Among selected patients admitted with cardiovascular disease in Nova Scotia for whom such individual-level and area-level data were available, lower individual-level income and place of residence emerged as independent predictors of higher rates of readmission to hospital for any cardiac cause over time, even after adjustment for differences in admission diagnosis, age, sex and co-morbid illness. Area-level income failed to predict readmission rates.

6.2 The Missing Pieces

These results emphasize the disparities in access to cardiac care and cardiovascular outcomes across Nova Scotia. Furthermore, these findings mirror the inequalities documented in other larger provinces. This would appear to support the notion that Canada's universal access health care system is less than perfect in ensuring uniform access to care for all Canadians and, similarly, does not guarantee equivalent outcomes.

One may therefore become resigned to accepting the viewpoint put forth by David Alter when he paraphrased George Orwell's *Animal Farm* and asserted that when it comes to Canada's socialized health care system, "not all Canadians will be equal and some Canadians will be less equal than others"(192). However, no system is or ever will be capable of ensuring absolutely uniform health access and outcomes across an entire population. This is what, after all, defines health inequalities – acceptable variations or disparities in health experience and outcomes between different population groups whether it be according to SES, geographic area, age, disability, sex, etc that are not the result of malicious intent or purposeful misdistribution of resources and hence do not provoke moral concern. Health inequities, on the other hand, refer to health inequalities that are deemed to be unfair, unjust, or not reflective of health needs and that imply a component of preventability(193). The Canadian health care system, like every other health care system in the world, will always be susceptible to health inequalities. There are certain factors associated with SES, geography and sex for instance that simply cannot be solved by the increased supply of health care alone and will continue to persist regardless of how perfect a health care system is. However, it is for us to realize that there are likely a number of provider- and patient-related factors that are truly unfair or unjust and that drive health inequities in the Canadian health care system and promote discrepancies above and beyond what would be deemed normally acceptable.

The results presented in this thesis along with those documented in studies from Quebec, Ontario and Alberta have established that socioeconomic and geographic disparities in cardiovascular care do exist across Canada regardless of provincial size or number of tertiary cardiac care centres. They emphasize the challenges that the Canadian health care system faces if it is to completely eliminate these disparities. However, if these discrepancies are to be minimized and possibly even eliminated, one must first differentiate those disparities that may be deemed acceptable inequalities from those differences that are more likely to be inequities resulting from various patient-related and provider-specific factors that may be avoided or remedied. This, however, cannot be accomplished using existing administrative and clinical data. Without expanding beyond the traditional boundaries of clinical outcomes research, we will remain stagnated at the level of describing inequities and generating hypotheses and a true understanding of causal mechanisms will continue to elude us. Therefore, acquisition of new data is required, data which will be collected with sole purpose of trying to determine why these inequities exist. The Socioeconomic and Acute Myocardial Infarction (SESAMI) study, proposed by Alter *et al.*, is an example of such an endeavour(145). They have prospectively gathered nuanced information through patient surveys, telephone interviews, hospital chart abstraction and longitudinal administrative data linkage with the expressed purpose of better understanding the intermediary pathways linking SES and cardiovascular outcomes(68, 143, 145, 170). Without this effort, we, as researchers, will remain mere reporters of inequities with little hope of ever answering the questions that we have posed, and health inequities in cardiovascular care will continue to persist.

6.3 Policy Implications

This thesis presents very important first pieces of information regarding the state of health care as it pertains to patients with IHD in Nova Scotia. It highlights the significant inequities in access to invasive cardiac care and the differences in rates of readmission to hospital that exist across geographic and socioeconomic strata in this province. Despite the importance of these findings and the seeming attractiveness of speculating on their policy implications, initiatives must be developed carefully and only once a better understanding of the mechanisms underlying such inequities has been gained.

In the past, the response to perceived geographic barriers to care has been to increase the supply of health care resources to those areas considered as being underserved. This has, in certain provincial jurisdictions, resulted in the construction of new cardiac catheterization and coronary revascularization centres. While this initiative would appear to offer improved access to invasive cardiac care resources in areas remote to the tertiary care centres, such decentralization has the potentially detrimental effect of destabilizing the economic underpinnings of academic centres upon which Canadians rely for advanced cardiac care. First of all, the cost efficiency afforded by a centralized model of care is lost when multiple centres are assigned the task of managing a disease process in the place of single centre. Secondly, the ensuing dilution of expertise may negatively affect outcomes at both the hospital level and the individual surgeon-level. Hannan *et al.* have previously shown a positive association between higher-volume surgeons and hospitals and lower risk-adjusted mortality rates(194, 195). Thus, the creation of new cardiac care centers centres in non-metropolitan urban areas or rural areas as a solution to the inequities found in Nova Scotia may not be the optimal response.

Further study is required in order to determine how best to minimize or eliminate inequities in cardiac care in Nova Scotia. Physician- and patient-related predictors of access to cardiac catheterization and increased rates of readmission must be ascertained using survey questionnaires. Health care providers would be provided with an assortment of clinical scenarios and asked how they would respond, focusing specifically on various aspects of patient assessment and decision management. Similarly, patient and non-patient residents would be provided with different clinical situations in which their willingness to seek care and their perception of barriers to care would be determined. With the highly centralized model of advanced cardiac care delivery found in this province and the wide variety of physician types and management styles involved in the care of patients with IHD, Nova Scotia provides an ideal setting in which to study such factors. It is anticipated that the results of these studies will better inform policy initiatives with the aim of not only increasing access to care but also improving overall patient outcomes.

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