Factors Impacting the Referral to, Enrollment in, and Completion of Cardiac Rehabilitation within Northwest, Ontario

by

Dallon T. Lamarche

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Approval

The Undersigned Faculty Committee approves the thesis of

Dallon Lamarche

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Dr. Anna Koné, Department of Health Sciences, Supervisor

Dr. Lindsay Galway, Department of Health Sciences, Thesis Committee Member

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Dr. Pete Brink, Department of Health Sciences, Thesis Committee Member

Author's Declaration of Originality

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

Abstract

Background: Northwest Ontario has higher rates of cardiac hospitalization compared to Southern Ontario for reasons not fully understood. However, cardiac rehabilitation (CR), a proven secondary prevention strategy, remains underutilized in Northwest Ontario. This study therefore aims to evaluate CR utilization and factors that impact access to CR. We also examined how CR may impact cardiac-related rehospitalization in Northwest Ontario. **Methods:** A retrospective cohort study was selected to analyze patients discharged with a cardiac-related index event at the Thunder Bay Regional Health Sciences Centre (TBRHSC) between July 2014 and December 2017 and subsequently followed until February 2023. Binary logistic regression and Cox proportional hazards models were used to identify factors influencing CR referral, enrollment, completion, and time to cardiac-related rehospitalization. **Findings:** Of the 448 eligible patients, 93.1% were referred to CR, of those only 51.7% enrolled, and of those that enrolled about 41.9% completed the program. The overall completion rate from the 448 eligible patients was therefore 19.9%. Enrollment was positively associated with having a partner ($OR=3.14$, $p<0.01$) and being female ($OR=2.06$, $p<0.01$) and negatively with drive time ($OR=0.97$, $p=0.03$). A family history of heart disease was the only factor associated with CR completion ($OR=2.18$, $p=0.02$). CR completion delayed time to rehospitalization ($HR=0.69$, $p=0.05$), with a 31% lower risk of rehospitalization among those completing CR in our unadjusted analysis. However, after adjusting for covariates, this impact became non-significant. **Conclusion:** Although referral rates are high due to a systematic process at the TBRHSC, CR enrollment and completion in Northwest Ontario remain suboptimal. Barriers include gender disparities and geographic accessibility. While completing CR appears to reduce cardiac-related rehospitalization, the overall impact on mitigating the cardiovascular disease burden in

Northwest Ontario may be limited due to low CR completion rates. Further research is needed to quantify the long-term benefits of CR completion and identify strategies to improve completion rates in this region.

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To my remarkable partner, Heather, I owe my deepest thanks. Your constant encouragement, endless patience, and gracious understanding during the countless hours I dedicated to this work have meant more to me than words can express. Without your unwavering support, I might not have found the motivation to see this through. As this chapter of our lives draws to a close, I look forward with excitement to the bigger and greater goals we've always dreamed of achieving together. Onwards to new adventures.

This research journey has been ambitious and deeply fulfilling. After five years of relentless dedication, I am eager to take a well-deserved break. However, I have gained so much knowledge through my research and learned a great deal about the state of cardiovascular health here in Northern Ontario. Once I've had the chance to rest fully, I am committed to expanding on my thesis work, applying my knowledge and expertise in the cardiovascular sciences to serve and benefit the people of Northern Ontario.

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Chapter 1: Introduction

1.1 Background & Significance

Cardiovascular diseases are the leading cause of mortality worldwide, accounting for approximately one-third (31%) of all global deaths (World Health Organization, 2019). Among these, ischemic heart disease—also known as coronary heart disease—is the most prevalent, contributing to nearly 16% of global deaths (Roth et al., 2017; World Health Organization, 2019). In Ontario, over 1 million individuals are living with ischemic heart disease (Canadian Chronic Disease Surveillance System, 2018g). Notably, regional discrepancies exist in hospitalization rates due to ischemic heart disease, particularly within the Northwest Local Health Integration Network (NWLHIN), the health authority that spans Northwest Ontario (Health Quality Ontario, 2017; Public Health Ontario, 2019d, 2021a).

Although the global mortality rate due to ischemic heart disease has been declining—an improvement reflected in both Canada and Ontario—the NWLHIN continues to report higher age-standardized rates for ischemic disease hospitalization (377 cases per 100,000 population [95% confidence interval (CI): 1121-1202 cases]) compared to the rest of Ontario (218 cases per 100,000 population [95% CI: 773 to 781 cases]) (Public Health Ontario, 2019d, , 2024a). The causes of this discrepancy remain unclear; however, significant risk factors for ischemic heart disease are known to be greater in the NWLHIN than other regions of Ontario. These risk factors include alcohol consumption, smoking, diabetes, hypertension, and obesity, which may be compounded by adverse social determinants of health such as lower employment rates, lower educational attainment, and a higher proportion of income spent on shelter (Public Health Ontario, 2018d, 2018a, 2019c, 2019b, 2020a, 2024a, 2021c, 2021b). Additionally, rehospitalizations following an initial cardiac-related event are reported to be higher in Northern Ontario compared to Southern Ontario, with crude rates per 100 person-years of 89.5 vs. 63.5 for acute myocardial infarction, 162.3 vs. 133.7 for heart failure, 93.0 vs. 73.7 for atrial fibrillation, and 76.0 vs 57.1 for stroke, respectively (Donio et al., 2019).

Secondary prevention strategies are crucial for managing cardiovascular disease, including ischemic heart disease, after an initial cardiovascular event. Cardiac rehabilitation (CR), in particular, is as efficacious as surgical (e.g., percutaneous coronary intervention) and pharmacological (e.g., aspirin, statins, beta-blockers) interventions, offering additional benefits such as slowing, attenuating, or reversing disease progression by improving endothelial function (Matsuzawa & Lerman, 2014). It is a proven, cost-effective secondary prevention strategy that reduces mortality by 25% and rehospitalization by 18%, while also enhancing health-related quality of life (Anderson et al., 2016). Despite its efficacy, CR remains underutilized (Ades et al., 2017; Candido et al., 2011; Martin et al., 2012; Suaya et al., 2007).

To date, factors influencing the referral, enrollment, and completion of a CR program in Northwest Ontario remain unclear due to a paucity of research. While barriers to CR have been extensively studied in Southern Ontario, the context within Northwest Ontario has not been thoroughly examined. Northwest Ontario is characterized by a large geographical footprint, sparse population density, and limited transportation infrastructure, which creates unique challenges for accessing healthcare. Unlike Southern Ontario, where healthcare facilities are more concentrated and accessible, residents in the Northwest often face significant travel distances, adverse winter weather conditions, and fewer available healthcare resources. These geological access issues, combined with traditional barriers such as sociodemographic and health system factors may contribute to existing inequities. Therefore, this thesis aims to evaluate process measures, including referral, enrollment, and completion of CR, as well as outcome indicators such as time to cardiac-related rehospitalization on eligible patients residing within Northwest Ontario.

1.2 Research Questions & Objectives

Utilizing healthcare databases from the Thunder Bay Regional Health Sciences Centre (TBRHSC)—Northwest Ontario's single CR program—and provincial databases, this thesis will identify patients eligible for CR residing within Northwest Ontario. Their sociodemographic profiles will be assessed to characterize barriers to access. Specifically, this thesis aims to describe how sociodemographic and geographic factors influence referral to, enrollment in, and completion of a CR for eligible patients residing within the TBRHSC catchment area. Overall, this thesis will assess whether *social and/or geographical inequities exist in accessing CR within Northwest Ontario.* The specific research questions are:

1. What proportion of eligible patients within Northwest Ontario are referred to, enroll in, and complete CR, and how do sociodemographic and geographical factors affect these stages?
2. After controlling for sociodemographic and geographical factors, does completing CR influence time to rehospitalization?

Chapter 2: Literature Review

A comprehensive literature review was conducted in Spring of 2020 to understand the current body of knowledge regarding referral, enrollment, and completion of CR, along with associated factors and their impact on time to rehospitalization. Relevant keywords such as *heart disease*, *socioeconomic status*, *referral*, *enrollment*, *completion*, and *cardiovascular rehabilitation* were used to search multiple databases. The primary search strings included "cardiac rehabilitation" and "socioeconomic factors". Table 2.1 provides a detailed description of the search strings employed.

Table 2.1 Databases used for literature review.

Search engine	**Search string (keywords and operators)**
PubMed	Entered into search bar: *"((("cardiac rehabilitation"[Mesh] AND "socioeconomic factors"[Mesh]) AND "Humans"[Mesh]) AND "socioeconomic factors"[All Fields]) OR (("cardiac rehabilitation"[All Fields] AND ("socioeconomic factors"[All Fields] OR "socioeconomic status"[All Fields])) NOT medline[sb])*.
Web of Science	Entered into search bar: "Cardiac: *"cardiac Rehabilitation AND (socioeconomic status OR socioeconomic factors)*.
ProQuest	Databases selected: Nursing & Allied Health Database, Health & Medical Collection, Healthcare Administration Database, Public Health Database, Social Science Database. Entered into search bar: *"cardiac rehabilitation" AND "socioeconomic factors"*. Limiters added: scholarly journal, articles, reviews, evidence-based health care, literature review, English, year (January 1, 2000 to present).
CINAHL	Entered into search bar: *"cardiac rehabilitation AND socioeconomic factors"*.
Embase	Entered into search bar: *(cardiac rehabilitation and (socioeconomic factors or socioeconomic status))*.

In addition to targeted studies on CR, we included articles that present population-level statistics on heart disease identified during the initial search. The subsequent sections will outline the epidemiology of heart disease at the global, national, and provincial levels. We will then discuss the efficacy of CR and barriers to access, with a particular emphasis on Northwest Ontario where data is available.

2.1 Ischemic Heart Disease: The Largest Burden of Cardiovascular Disease

Cardiovascular diseases remain the leading cause of global mortality, accounting for approximately 31% of all deaths worldwide (Roth et al., 2017; World Health Organization, 2019). The World Health Organization defines cardiovascular diseases as a group of disorders affecting the heart and blood vessels, including ischemic heart disease, cerebrovascular disease (or stroke), peripheral arterial disease, rheumatic heart disease, congenital heart disease, deep vein thrombosis, and pulmonary embolism (World Health Organization, 2017). These conditions share common risk factors such as tobacco use, unhealthy diet, obesity, physical inactivity, harmful use of alcohol, hypertension, diabetes, and hyperlipidemia (World Health Organization, 2017).

Ischemic heart disease, also known as coronary artery disease, is the most fatal among the cardiovascular diseases, contributing to nearly 16% of all global deaths (World Health Organization, 2019). It is characterized by the accumulation of fatty plaques—a process known as atherosclerosis—within the coronary arteries, which supply blood to the heart muscle (Bentzon et al., 2014). This plaque buildup narrows the arteries, reducing blood flow to the myocardium. Complete occlusion can lead to myocardial infarction (heart attack), potentially resulting in disability or death. Even partial occlusion can cause symptoms such as angina and chest pain, indicative of ischemic heart disease. Untreated chronic atherosclerosis over decades may progress to congestive heart failure, where the heart cannot pump sufficient blood to meet the body’s needs.

2.1.1 Global Epidemiology of Ischemic Heart Disease

Ischemic heart disease has been the leading cause of death globally for the past two decades (World Health Organization, 2019). In 2019, it was responsible for approximately 8.9

million deaths, up from 6.7 million in 2000, representing about 16% of all deaths worldwide (World Health Organization, 2019). While ischemic heart disease is the primary cause of mortality in most countries regardless of development level, its prevalence is decreasing in highly developed countries such as Australia, Canada, Japan, United Kingdom, and the United States (Roth et al., 2017). Understanding this global trend provides a foundation for exploring regional discrepancies, such as why Northwest Ontario continues to face significant challenges with ischemic heart disease outcomes despite these declining trends.

Many high-income countries have reported significant declines in mortality rates due to ischemic heart disease between 1990 and 2015 (Roth et al., 2017; World Health Organization, 2019). For example, in the United States, the mortality rate decreased from 214.6 deaths per 100,000 people in 2000 to 153.4 deaths per 100,000 in 2019 (World Health Organization, 2019). This decline is attributed to advancements in primordial and primary prevention and intervention strategies. However, evidence suggests that these global declining trends may have plateaued (Roth et al., 2017). The plateau in high income countries raises questions about whether similar stagnation may be observed in Northwest Ontario and whether current interventions adequately address regional needs.

Conversely, deaths due to ischemic heart disease continue to rise or remain high in less developed countries (Roth et al., 2017). For instance, in Mexico, the mortality rate increased from 54.5 deaths per 100,000 in 2000 to 91.1 deaths per 100,000 in 2019 (World Health Organization, 2019). The economic burden is substantial; in 2010, the global cost of cardiovascular disease was estimated at US $863 billion, with projections suggesting a 22% increase to US $1,044 billion by 2030 (Bloom et al., 2011). This contrast between high- and low-income countries highlights the importance of addressing regional barriers in Northwest Ontario, where economic and geographical factors may mirror challenges faced in less developed regions.

In 2015, ischemic heart disease had an estimated prevalence of 110.5 million cases worldwide, accounting for more than a quarter of all cardiovascular diseases cases (Roth et al., 2017). Eastern Europe and Central Asia reported the highest prevalence, with 4,140 and 3,158 cases per 100,000, respectively, while Central sub-Saharan Africa, Southern Latin America, and high-income Asia Pacific had the lowest prevalence rates at 622, 690, and 708 cases per 100,000, respectively (Roth et al., 2017). Similarly, Eastern Europe and Central Asia had the highest age-standardized mortality rates due to ischemic heart disease, at 326 and 336 deaths per 100,000, respectively, whereas high-income Asia Pacific, Western Europe, and Australasia reported the lowest rates at 45, 80, and 84 deaths per 100,000, respectively (Roth et al., 2017). These regional differences highlight the importance of studying localized epidemiology, such as in Northwest Ontario, where unique risk factors and healthcare access barriers may contribute to higher rates of ischemic heart disease.

2.1.2 Epidemiology of Ischaemic Heart Disease in Canada

Canada, with a population of approximately 38 million people (Statistics Canada, 2020), had over 1.5 million individuals diagnosed with ischemic heart disease in 2000, increasing to almost 2.5 million in 2016 (Canadian Chronic Disease Surveillance System, 2018f). Despite the growing prevalence, the annual incidence has declined from 221,870 new cases in 2000 to 158,990 in 2016, representing an age-standardized incidence rate decrease from 1,245 to 629 cases per 100,000 population (Canadian Chronic Disease Surveillance System, 2018ij). This decline is similar to trends observed in other developed countries (Roth et al., 2017).

The mortality rate due to ischemic heart disease has also decreased, from 160.5 deaths per 100,000 in 2000 to 107.1 deaths per 100,000 in 2016 (World Health Organization, 2019). However, the absolute number of deaths remains high, increasing from about 86,310 deaths in 2000 to 115,910 deaths in 2016 (Canadian Chronic Disease Surveillance System, 2018e). This is concerning, as individuals with ischemic heart disease are three to four times more likely to die from any cause than those without the disease, highlight the substantial health risks and ongoing burden associated with this condition (Public Health Agency of Canada, 2017b). This elevated risk emphasizes the importance of effective secondary prevention strategies, such as cardiac rehabilitation, to mitigate mortality and improve quality of life for individuals with ischemic heart disease.

Incidence and mortality rates vary among Canada's provinces and territories (Filate et al., 2003). In 2016, the Northwest Territories and Alberta had the highest age-standardized incidence rates at 752 and 703 cases per 100,000, respectively, while Nunavut and Prince Edward Island had the lowest at 492 and 449 cases per 100,000, respectively (Canadian Chronic Disease Surveillance System, 2018i). The highest age-standardized all-cause mortality rates among those with ischemic heart disease were in Saskatchewan (3,211 deaths per 100,000 in 2015) and Nunavut (3,028 deaths per 100,000 in 2016) while the lowest were in the Yukon (1,248 deaths per 100,000 in 2016) and Prince Edward Island (1,373 deaths per 100,000 in 2016) (Canadian Chronic Disease Surveillance System, 2018e). The discrepancy observed in Nunavut—having the lowest incidence rates but the highest mortality rates—may reflect systemic challenges in accessing timely and effective healthcare services. These challenges, coupled with high rates of comorbidities and geographic barriers, likely contribute to poorer outcomes for those diagnosed with ischemic heart disease in this region (Deering et al., 2009; National Collaborating Centre for Indigenous Health, 2019).

In 2010, the direct and indirect costs of cardiovascular disease in Canada were estimated at $13 billion and $644 million, respectively (Public Health Agency of Canada, 2017a). Specifically, ischemic heart disease and related conditions (e.g., acute myocardial infarction, atherosclerosis, angina pectoris, hypertension, and heart failure) imposed an estimated total cost of almost $4.5 billion on the Canadian healthcare system (Public Health Agency of Canada, 2017a). Sparse information exists on the economic burden in Ontario beyond this report, which estimated the total cost of ischemic heart disease in Ontario at nearly $1.7 billion (Public Health Agency of Canada, 2017a). These statistics support the need to address the growing prevalence and economic burden of ischemic heart disease in Canada, particularly in underserved regions like Northwest Ontario, where geographic and systemic barriers may exacerbate disparities in access to effective secondary prevention strategies, such as cardiac rehabilitation.

2.1.3 Epidemiology of Ischemic Heart Disease in Ontario

Ontario, Canada's most populous province, had approximately 13.45 million residents in 2016 (Statistics Canada, 2017). In 2000, 646,570 Ontarians were living with ischemic heart disease, representing 43% of all Canadian cases. By 2016, this number exceeded 1 million (Canadian Chronic Disease Surveillance System, 2018j, 2018g). Like global and national trends, the prevalence continues to grow, despite a steady decline in incidence rates. The age-standardized incidence rate decreased from 1,308 cases per 100,000 Ontarians (88,620 new cases) in 2000 to 580 cases per 100,000 (58,660 new cases) in 2016 (Cancer Care Ontario & Public Health Ontario, 2019).

Recent trends in cardiovascular disease hospitalizations reported by Public Health Ontario suggest continued declines in ischemic heart disease incidence rates up to 2022 (Public Health Ontario, 2022). This decrease likely reflects advancements in managing key risk factors such as hypertension, hyperlipidemia, and smoking cessation, alongside widespread use of effective pharmacological and interventional therapies. Public health campaigns promoting public awareness and early detection initiatives may also contribute to these trends.

These advancements are also evident in mortality data. The age-standardized all-cause mortality rate among Ontarians with ischemic heart disease decreased by 20.1% during the same period, 2,026 deaths per 100,000 (35,260 total deaths) in 2000 to 1,619 deaths per 100,000 (46,260 total deaths) in 2016 (Canadian Chronic Disease Surveillance System, 2018h). This improvement reflects significant progress in secondary prevention and acute care, such as the increased availability of revascularization procedures and improved pharmacological treatments. However, the absolute number of deaths has increased, likely due to the aging population and the growing prevalence of ischemic heart disease, highlighting the continued need for sustained public health interventions and healthcare resources to address this persistent burden effectively.

2.1.4 Epidemiology of Ischemic Heart Disease in Northwest Ontario

In the NWLHIN, the mortality rate due to ischemic heart disease decreased by approximately 40% between 2003 and 2015, paralleling the 46% decrease observed across Ontario (Public Health Ontario, 2019d). However, mortality rates in the NWLHIN remain higher than the provincial average (Public Health Ontario, 2019d, 2021a). In 2015, the NWLHIN reported about 108 deaths per 100,000 population due to ischemic heart disease, compared to approximately 88 deaths per 100,000 in Ontario overall (Public Health Ontario, 2019d). Premature mortality rates also differ, with the NWLHIN reporting 415.2 healthy life years lost per 100,000 due to cardiovascular disease, compared to 288.2 per 100,000 for Ontario as a whole (Public Health Ontario, 2019e).

While specific incidence and prevalence rates for ischemic heart disease in the NWLHIN are unavailable, hospitalization rates are higher compared to the provincial average (Public Health Ontario, 2021a). In 2019, the NWLHIN reported nearly 395 hospitalizations per 100,000 population for ischemic heart disease, compared to 277 per 100,000 in Ontario (Public Health Ontario, 2021a). The higher hospitalization rates in the NWLHIN may partly reflect differences in population demographics. The NWLHIN has a higher proportion of older adults (18.1% aged 65 and over compared to the provincial average of 16.7%) and a greater prevalence of multiple chronic conditions (24.5% versus 19.7%) (Health Quality Ontario, 2017; Ontario Health at Home, 2020). Older populations are more susceptible to ischemic heart disease, and comorbidities can complicate health status, increasing the likelihood of hospitalizations. Additionally, rehospitalizations appear to be more frequent in the NWLHIN compared to Southern Ontario, for reasons not yet fully elucidated (Donio et al., 2019).

2.2 Ischemic Heart Disease Risk Factors

Approximately three-quarters of deaths related to ischemic heart disease are preventable. Modifiable risk factors associated with its development include physical inactivity, hypercholesterolemia (Castelli et al., 1992), smoking (Novello, 1990), diabetes (Haffner, 1999; Wagenknecht et al., 1998), hypertension (Assmann & Schulte, 1988; Chobanian & Alexander, 1996), obesity (Kumada et al., 2003; Matsuzawa et al., 1995), and stress (Brotman et al., 2007; Steptoe & Kivimäki, 2012). Non-modifiable risk factors include male sex (Lloyd-Jones et al., 1999), older age (Sanchis-Gomar et al., 2016), genetic predisposition or family history (Antonarakis & Beckmann, 2006; Kullo & Ding, 2007), and ethnic origins such as African

Americans, Hispanics, Latinos, and Southeast Asian populations (Carnethon et al., 2017; Rodriguez et al., 2014; Volgman et al., 2018)). Political, environmental, economic, and social determinants further influence ischemic heart disease risk (Rajagopalan et al., 2018).

In the NWLHIN, modifiable risk factors such as hypertension, diabetes, obesity, smoking, and heavy alcohol consumption are more prevalent, with hospitalization rates significantly exceeding provincial averages. For instance, the age-standardized prevalence of diabetes in the NWLHIN is 12.6%, compared to 11.6% provincially, while hospitalization rates for diabetes are 280 cases per 100,000, more than double Ontario's average of 104 cases per 100,000 (Public Health Ontario, 2020b, 2021b). Similarly, smoking prevalence in the NWLHIN is 18.7%, compared to 13.0% provincially (Public Health Ontario, 2018d). These disparities highlight the disproportionate burden of ischemic heart disease in the NWLHIN.

Hypertension. Hypertension is a leading risk factor for ischemic heart disease. Individuals with hypertension have nearly double the odds (odds ratio [OR] 1.91) of developing ischemic heart disease compared to those with normal blood pressure (Yusuf et al., 2004). Defined as systolic blood pressure >140 mm Hg systolic and/or diastolic pressure >90 mm Hg, hypertension promotes atherosclerosis through inflammatory and mechanical effects on arterial walls (Chobanian & Alexander, 1996).

Between 2000 and 2016, the national age-standardized prevalence of hypertension in Canada increased from 18.0% to 23.6%, while the incidence rate per 100,000 decreased from 3,284 to 1,975 (Canadian Chronic Disease Surveillance System, 2018c, 2018d). In Ontario, the prevalence rose from 18.8% (1.560 million cases) in 2000 to 24.2% (3.034 million cases) in 2016, with incidence rates following national declines (Canadian Chronic Disease Surveillance System, 2018d). Notably, the NWLHIN has lower prevalence and incidence rates of hypertension than provincial averages, yet hospitalization rates remain disproportionately high at 29 per 100,000 compared to Ontario's 17.5 per 100,000 (Public Health Ontario, 2018b, 2020d, 2021c). This discrepancy highlights potential gaps in hypertension management and access to care in the NWLHIN.

Diabetes. Diabetes is a critical risk factor, doubling the likelihood of ischemic heart disease (Johansson et al., 2016; Yusuf et al., 2004). Globally, diabetes prevalence is projected to rise from 6.4% (285 million people) in 2010 to rise to 7.7% (439 million people) by 2030 (Shaw et al., 2010). In Canada, the prevalence increased from 4.77% (1.315 million people) in 2000 to 8.02% (3.170 million people) in 2016, with similar trends in Ontario (Canadian Chronic Disease Surveillance System, 2018a, 2018b). The national age-standardized incidence rate decreased slightly from 660 cases per 100,000 in 2000 to 616 cases per 100,000 in 2016 (Canadian Chronic Disease Surveillance System, 2018a). Although the NWLHIN's prevalence and incidence rates align with provincial figures, hospitalization rates for diabetes far exceed Ontario's average, indicating greater disease severity or complications in the region

Obesity. Obesity, defined as a body mass index [BMI] >30 kg/m^2, independently raises ischemic heart disease mortality risk (Guh et al., 2009; Mann et al., 2006). Between 1985 and 2011, obesity rates in Canada nearly tripled, with adult obesity increasing from 6.1% to 18.3% (Twells et al., 2014). Projections indicate that obesity rates will continue to rise until at least 2030 (Bancej et al., 2015; Lebenbaum et al., 2018). In 2015, approximately one-quarter of Canadians were obese; however, when combined with overweight individuals, the prevalence increased to 62.1% (Bancej et al., 2015; Public Health Agency of Canada, 2011). In Ontario, the NWLHIN reports a self-reported obesity prevalence of 34.4%, significantly higher than the provincial average of 26.5% (Public Health Ontario, 2018a). This disparity highlights a need for targeted obesity prevention and management strategies within the NWLHIN.

Smoking. Smoking elevates ischemic heart disease risk, with current smokers having nearly triple the odds (OR 2.87) of disease compared to non-smokers (Yusuf et al., 2004). Despite national declines in smoking prevalence, the NWLHIN's smoking rate remains higher than Ontario's average, at 18.7% versus 13.0% in Ontario overall (Public Health Ontario, 2018d). Smoking cessation programs tailored to the NWLHIN population could mitigate this disparity.

Alcohol consumption. Excessive alcohol consumption adversely affects cardiovascular health (Bell et al., 2017). While moderate alcohol consumption may confer some benefits, heavy drinking significantly worsens outcomes. In the NWLHIN, 735 per 100,000 people were hospitalized for alcohol-related conditions, including ischemic heart disease—over three times the provincial rate of 200 per 100,000 (Public Health Ontario, 2020a). This statistic reflects conditions partially attributable to alcohol, suggesting the need for targeted interventions addressing high-risk drinking behaviours in the region.

Socioeconomic factors. Socioeconomic disparities, including lower educational attainment, higher unemployment, and increased housing costs, contribute to the NWLHIN's elevated ischemic heart disease burden. For instance, cardiovascular hospitalization rates differ by 548 per 100,000 between the most and least marginalized groups in the NWLHIN, compared to a 382 per 100,000 difference provincially (Public Health Ontario, 2019a). Addressing these disparities requires comprehensive strategies targeting the social determinants of health.

2.3 Preventing Cardiovascular Disease

Given the substantial health and economic burden of cardiovascular disease, various strategies have been developed to prevent or attenuate its development at the primordial, primary, secondary, and tertiary levels. These interventions aim to reduce or mitigate cardiovascular disease primarily through a combination of smoking cessation, healthy diet, regular physical activity, and stress reduction (Burke et al., 2011; Gupta & Wood, 2019). Collectively, these strategies have contributed to approximately 60% of the reduction in the incidence of ischemic heart disease over the past century (Gupta & Wood, 2019).

Primordial interventions. Primordial interventions target the root causes of ischemic heart disease by preventing the emergence of risk factors (Gupta & Wood, 2019). For instance, increasing taxes on tobacco products by 10% has been shown to reduce tobacco consumption by 4 to 8% (Shrivastav et al., 2012). This approach is particularly effective in discouraging smoking initiation among adolescents, thereby reducing the likelihood of long-term smoking (Bloom et al., 2011; DeCicca et al., 2008; Shrivastav et al., 2012).

However, tobacco taxation as a public health strategy raises ethical considerations, particularly for individuals with lower socioeconomic status, who have higher smoking rates and may experience greater financial hardship because of these measures (Hiscock et al., 2012). To address this, taxation policies should be paired with accessible cessation support programs, such as subsidized nicotine replacement therapy and counselling, to ensure equitable access to resources that help individuals quit smoking while reducing unintended economic strain.

Primary interventions. Primary interventions focus on promoting lifestyle changes, pharmacological therapy, or a combination of both to prevent the onset of disease. Lifestyle changes play a foundational role in primary prevention and include adopting a heart healthy diet, engaging in regular physical activity, maintaining a healthy weight, reducing stress, and avoiding tobacco use (Burke et al., 2011). For instance, dietary modifications such as increasing the intake of fruits, vegetables, and whole grains while reducing saturated fats and sodium have been shown to lower cardiovascular risk factors (Dalen & Devries, 2014). Similarly, regular physical exercise, such as brisk walking or cycling, can improve lipid profiles, reduce blood pressure, and promote overall cardiovascular health (Warbuton et al., 2006).

In addition to lifestyle changes, pharmacological therapies such as the use of statins (e.g., Lovastatin) have been demonstrated to prevent incident ischemic heart disease events regardless of an individual's genetic risk. Statins can reduce the risk of ischemic heart disease by 13% in low-risk, 29% in intermediate-risk, and 48% in high-risk individuals (Mega et al., 2015). Prescribing statins to patients with genetic hypercholesterolemia is an example of primary prevention, addressing elevated cholesterol levels that lifestyle changes alone may not sufficiently manage.

Secondary interventions. Secondary interventions aim to modify the impact of diagnosed ischemic heart disease by mitigating disease progression (Karunathilake & Ganegoda, 2018). Statins are also used in secondary prevention to prevent further deterioration in individuals with established disease. CR, the focus of this thesis, is another example of a secondary intervention. It is an exemplary secondary prevention strategy, offering benefits comparable to pharmacological (Antithrombotic Trialists' Collaboration, 2002; LaRosa et al., 1999) and cardiac catheterization interventions (Boden et al., 2007; Hambrecht et al., 2004). Moreover, CR promotes lifestyle modification, medication adherence, smoking cessation, and improves health-related quality of life (Clark et al., 2005).

Tertiary interventions. Tertiary interventions involve advanced care following the diagnosis of ischemic heart disease, focusing on pain management, extending life expectancy, and enhancing quality of life (Karunathilake & Ganegoda, 2018). Procedures such as coronary artery bypass grafting and percutaneous coronary intervention are examples of tertiary interventions. These interventions are often more expensive than secondary prevention strategies. In contrast, secondary prevention can be more cost-effective by reducing hospitalizations and avoiding invasive surgical procedures.

Increasing evidence indicates that primordial and primary interventions are among the most impactful ways to improve public health outcomes (Centers for Disease Control and Prevention, 2010, 2011, 2012, 2018). However, in the absence of effective primordial and primary interventions, or when ischemic disease has already developed, secondary prevention strategies are critical for maintaining the highest quality of life in those diagnosed with the disease.

2.4 Cardiac Rehabilitation: An Important Secondary Prevention Strategy

Chronic diseases such as cardiovascular and ischemic heart disease are not curable and cannot be fully addressed by acute care alone. Secondary prevention strategies are essential for ongoing care following an initial cardiovascular event, aiming to reduce the risk of recurrent events.

2.4.1 Definition

Cardiac rehabilitation provides recovery support for patients following a cardiovascular event. It is broadly defined as a comprehensive intervention that uses a multidisciplinary approach to address multiple cardiovascular disease risk factors, providing educational, social, and physical activity support to manage the disease effectively (Thompson & Clark, 2009).

Exercise is a cornerstone of CR programs, as structured physical activity has been shown to improve cardiovascular fitness, reduce risk factors such as hypertension and hyperlipidemia, and lower the likelihood of future cardiac events (Lavie et al., 2015; Taylor et al., 2004).

In Canada, the Canadian Heart Health Strategy and Action Plan describes CR as a multifaceted approach that “includes comprehensive targeted cardiovascular risk factor therapies, behaviour modification strategies to sustain healthy lifestyles and promote pharmacological adherence, and therapeutic exercise and physical activity programs” (Arthur et al., 2010, p. 38). Similarly, the Canadian Association of Cardiac Rehabilitation defines it as “the enhancement and maintenance of cardiovascular health through individualized programs designed to optimize physical, psychological, social, vocational, and emotional status. The process includes the facilitation and delivery of secondary prevention through risk factor identification and modification in an effort to prevent disease progression and recurrence of cardiac events” (Dafoe et al., 2006, p. 906). Exercise training, which includes aerobic and resistance exercises tailored to individual needs, is a core component of these programs, contributing to improved functional capacity and quality of life.

2.4.2 Cardiac Rehabilitation Delivery Models

Cardiac rehabilitation generally consists of three phases: Phase I, Phase II, and Phase III. Phase I refers to inpatient CR immediately following the cardiovascular event, performed during hospitalization. Phase II occurs in an outpatient setting following discharge from a cardiovascular hospitalization and involves medical supervision and monitored physical activity over a 3–6-month period. This phase is often the focus of health outcomes research due to its rigorous, multidisciplinary, and formalized nature. Lastly, Phase III is an ongoing, independent, unmonitored phase with periodic evaluation by a physician.

In Ontario, the most common model is a supervised site-based program, with more than 70% of programs situated in hospital settings (Polyzotis et al., 2012). Of these, nearly 70% also offer home-based CR programs (Polyzotis et al., 2012). Alternative models such as telehealth/internet-based care and home-based systems are also employed and have demonstrated significant success in British Columbia and Ontario (Anderson et al., 2017; Grace et al., 2014).

2.4.3 Eligibility for Cardiac Rehabilitation

Cardiac rehabilitation is recommended for patients diagnosed with myocardial infraction, angina, heart failure, or those who have undergone cardiovascular procedures such as coronary artery bypass grafting, percutaneous coronary interventions, and heart/lung transplants (Cardiac Care Network of Ontario, 2014; Hillis et al., 2011b; Levine et al., 2011; Piepoli et al., 2014; Smith et al., 2011). Specifically, the Standards for the Provision of Cardiovascular Rehabilitation in Ontario indicate that eligible patients include those with established cardiovascular disease, such as acute coronary syndrome (e.g., ST-segment elevation myocardial infarction, non-ST-segment elevation myocardial infarction, unstable angina), chronic stable angina, chronic stable heart failure, or those following heart procedures like percutaneous coronary or valvular intervention, coronary artery bypass grafting, cardiac valve surgery, cardiac transplant, or an implantation of a ventricular assist device (Cardiac Care Network of Ontario, 2014). Patients at high cardiovascular risk for a future events may also be indicated for CR (Cardiac Care Network of Ontario, 2014). Conversely, those not eligible include patients with unstable cardiovascular disease, palliative indications, or other medical conditions such as dementia.

2.4.4 Benefits of Cardiac Rehabilitation for Patient Outcomes

Comprehensive, multidisciplinary Phase II CR has been shown to reduce mortality and rehospitalizations while increasing health-related quality of life in patients with ischemic heart disease (Alter et al., 2017; Anderson et al., 2016; Clark et al., 2005; Hambrecht et al., 2004; Heran et al., 2011; Jolliffe et al., 2001; Lawler et al., 2011; Martin et al., 2012; Milani et al., 1996; Milani & Lavie, 2007; Taylor et al., 2004). The most recent Cochrane systematic review and meta-analysis of exercise-based CR for ischemic heart disease analyzed 47 studies with 10,794 randomized patients assigned to either exercise-based CR or usual care (e.g., pharmacological intervention and/or standard medical care). Following completion of the rehabilitation program, overall mortality was reduced by 13%, and cardiovascular mortality by 26% over the subsequent 12 months (Anderson et al., 2016).

Cardiac rehabilitation also reduces morbidity in the form of subsequent hospitalizations by 31% in the 12 months following program completion (Anderson et al., 2016; Hambrecht et al., 2004). For example, in a study of 101 men under 70 years of age with ischemic heart disease confirmed by angiography, participants were randomized to either 12 months of exercise-based CR or underwent percutaneous coronary intervention. The rehabilitation group had a 22.8% higher event-free survival and 67.9% reduction in healthcare costs (e.g., rehospitalization and coronary reinterventions) compared to the intervention group (Hambrecht et al., 2004).

Furthermore, exercise-based rehabilitation has been shown to reduce the progression of coronary atherosclerosis through enhanced coronary endothelial function and collateralization (Gielen et al., 2001; Matsuzawa & Lerman, 2014), contributing to improvements in aerobic fitness and symptom alleviation (Hambrecht et al., 2004). The benefits of completing Phase II rehabilitation are derived from the managing cardiovascular disease risk factors such as smoking, diet, physical activity, and stress (Lavie & Milani, 2011; Lawler et al., 2011).

The proven efficacy of CR has led to its endorsement in many international clinical guidelines (Amsterdam et al., 2014; Balady et al., 2011; Ezekowitz et al., 2017; Hillis et al., 2011a; Levine et al., 2011; Mosca et al., 2011; Piepoli et al., 2014, 2016; Smith et al., 2011; Wright et al., 2011; Yancy et al., 2013). Moreover, the benefits are greater with increased attendance—the more sessions attended, the better patient outcomes (Alter et al., 2017; Hammill et al., 2010; Martin et al., 2012, 2013). Therefore, it is not only important to refer eligible patients but also to ensure completion and adequate attendance in rehabilitation programs.

2.4.5 Referral, Enrollment, & Completion of Cardiac Rehabilitation

The benefits of CR are dependent on patient referral, enrollment, and completion of the program. The following sections provide an overview of the literature regarding these three aspects, as well as the factors and interventions influencing them.

Cardiac Rehabilitation Availability. A recent landmark study on worldwide CR availability found that, in 2016/2017, there were 5,753 rehabilitation programs operating globally, available in only about 50% of countries (Turk-Adawi et al., 2019a). Notably, in these countries, only one-third had a single program for the entire country, and half had fewer than five programs (Turk-Adawi et al., 2019a). The study highlighted those countries with the highest incidence of ischemic heart disease often had the lowest—or even non-existent—density of CR programs. This discrepancy between availability and demand has been noted previously (Gaziano et al., 2010; Ragupathi et al., 2017; Turk-Adawi et al., 2014).

In 2016/2017, Canada had approximately 170 CR programs (Turk-Adawi et al., 2019a). Availability varied widely between provinces, with limited programs in Newfoundland & Labrador and Québec, and none in the territories. In contrast, Ontario had an estimated 53 programs in 2015 (Candido et al., 2011; Grace et al., 2015), including Canada's largest program at the Toronto Rehabilitation Institute, accommodating up to 1,800 outpatients per week. However, in the NWLHIN—an expansive region covering approximately 47% of Ontario's landmass but with a population of just over 235,000—only one known program is operating, with the capacity to accommodate 363 patients annually (Candido et al., 2011). Considering the geographic size and the distribution of the population, this limited capacity raises concerns about equitable access to CR services for residents of the region, particularly for those in remote and rural areas.

Cardiac Rehabilitation Capacity. Globally, the 5,753 programs offering Phase II rehabilitation had an estimated capacity to accommodate 1,655,083 patients annually (Turk-Adawi et al., 2019). To meet the needs of all incident cases of ischemic heart disease, nearly 19 million rehabilitation spots would be required (Roth et al., 2017). In Canada, the capacity was approximately 51,000 patients in 2016/2017 (Supervia et al., 2019; Turk-Adawi et al., 2019), representing about 56% of the 91,030 incident cases reported (Turk-Adawi et al., 2019). In Ontario, the capacity was 18,087 patients annually, only 34% of the 53,270 Ontarians eligible for multidisciplinary rehabilitation (Candido et al., 2011). The situation is worse in the NWLHIN, where the single provider can accommodate only 23.6% of eligible cardiovascular-related hospitalizations (Candido et al., 2011).

Cardiac Rehabilitation Referral. Referral is the greatest determinant of attendance at CR (Grace, Russell, et al., 2011). Referral is commonly defined as "an official communication between the health care provider, the cardiovascular rehabilitation program, and the patient that recommends timely assessment and participation in an outpatient program" (Thomas et al., 2007, p. 1626), a definition adopted by the Cardiac Care Network of Ontario (Grace, Chessex, et al., 2011). Referral generally follows a qualifying cardiovascular event and can occur before or after discharge, in various settings such as physician offices, inpatient units, or outpatient clinics (Grace, Chessex, et al., 2011; Swabey et al., 2004).

The Canadian Association of Cardiovascular Prevention and Rehabilitation and the Canadian Cardiovascular Society recommend that at least 85% of eligible patients be referred, and that 70% enroll in a rehabilitation program (Grace, Chessex, et al., 2011; Gravely-Witte et al., 2010). Despite capacity shortfalls, this secondary prevention strategy remains grossly underutilized (Bittner et al., 1999; Bunker & Goble, 2003; Grace et al., 2002; Suaya et al., 2007; Swabey et al., 2004). Global and national referral rates have not been well established due to data limitations (Grace et al., 2014). Although national databases have been developed, they remain limited in scope and data collected (Poffley et al., 2017). A Canadian national registry was established in 2005 to provide benchmark data, facilitate guideline adherence, improve patient outcomes, build a research database, and influence health policy (Grace et al., 2015). Despite the lack of comprehensive data, a systematic review estimated that referral rates average around 34%, though some studies report rates as high as 60% or more (Ali-Faisal et al., 2016; Cortés & Arthur, 2006; Viana et al., 2018).

Cardiac Rehabilitation Enrollment & Participation. National targets aim to increase enrollment in rehabilitation programs to at least 70% in the United States and Canada, and 85% in the United Kingdom (Ades et al., 2017; Bethell et al., 2007; Grace, Chessex, et al., 2011). Early estimates indicate that only 20 to 30% of referred eligible patients enroll (Beatty et al., 2018; Candido et al., 2011; Dafoe et al., 2006; Kotseva et al., 2018; Santiago de Araújo Pio et al., 2019; Suaya et al., 2007; Turk-Adawi & Grace, 2015), despite strong evidence supporting the benefits of rehabilitation (Anderson et al., 2016; Taylor et al., 2004). Specifically, in the United States, less than 20% of eligible patients enroll, remaining well below the recommended 70% (Ritchey et al., 2020). A recent update of the Millions Heart Campaign estimated that 25% of eligible patients enrolled, and only 27% of those who enrolled fully completed the program

(Ritchey et al., 2020). Similarly, in 2004, only 29% of eligible patients enrolled in the United Kingdom, below the 85% national target (Bethell et al., 2007). More recently, a meta-analysis reported overall enrollment rates of 42% (Samayoa et al., 2014) and participation rates of 66.5% of prescribed sessions (Oosenbrug et al., 2016).

In Ontario, an early study at the start of the millennium found that only 22% of eligible patients enrolled in a rehabilitation program (Swabey et al., 2004). However, subsequent studies have indicated that implementing various referral and enrollment strategies—such as automatic referral and use of liaisons—can achieve enrollment rates greater than 70% (Grace, Angevaare, et al., 2012; Parker et al., 2011). These strategies, however, have yet to be employed nationally. To our knowledge, no publicly available databases or peer-reviewed research have examined referral, enrollment, or completion rates in the NWLHIN or Northern Ontario, leaving information on this topic currently unknown.

Barriers to Cardiac Rehabilitation Referral, Enrollment, & Completion

Barriers to CR are commonly grouped into sociodemographic, medical, healthcare system, and psychosocial factors (Cortés & Arthur, 2006).

Sociodemographic-Related Barriers. Sociodemographic barriers primarily include age, sex, ethnicity, socioeconomic status, and place of residence.

Age. Age is an important factor influencing CR utilization, with barriers differing across age groups. Younger patients, particularly those under 65 years, experience unique challenges. Despite increasing rates of cardiovascular disease in younger adults, this demographic often has lower enrollment and completion rates compared to older adults (Balady et al., 2011, Jackson et al., 2005). Younger patients are frequently in the workforce and may hold full-time jobs, which complicates their ability to attend traditional, in person CR sessions during standard business hours (Harrison et al., 2015; Turk-Adawi et al., 2014). Additionally, younger adults are more likely to have caregiving responsibilities, such as raising children, furthering limiting their availability to prioritize CR participation (Bibeau et al., 2011). These competing demands highlight the need for more flexible CR delivery models, such as hybrid or home-based programs, to accommodate their schedules.

In contrast, older adults often face health-related barriers, such as comorbidities, frailty, and functional limitations, which can affect their referral and adherence to CR programs (King et al., 2001; Shanmugasegaram et al., 2013). Older individuals may also perceive CR as less beneficial due to a lack of education or misconceptions about its relevance to their age group (Clark et al., 2013). This highlights the importance of tailored interventions that address both logistical and health-related barriers specific to different age groups. Research indicates that both groups, younger adults due to time constraints and older adults due to health challenges, would benefit from targeted strategies, including virtual or hybrid programs and improved education on CR benefits (Anderson et al., 2016; Grace et al., 2002). Recognizing the age-specific challenges is important to improve CR participation and outcomes.

Sex & Gender. Disparities in CR utilization between men and women remain a significant challenge in Canada. It is important to distinguish between sex, which refers to biological differences (e.g., chromosomes, hormones, and reproductive anatomy), and gender, which encompasses sociocultural roles, behaviours, and expectations. Both sex and gender contribute to the observed inequities in CR participation.

Women may experience differences in cardiovascular disease presentation and progression, which can lead to delayed diagnosis and under referral to CR programs (Supervía et al., 2017). Women in Canada are 25% less likely than men to enroll in CR despite being equally eligible, highlighting systemic disparities (Supervía et al., 2017). Sociocultural factors linked to gender further exacerbate these disparities. Women are more likely to bear caregiving responsibilities, which constrain their ability to prioritize CR participation (Castellanos et al., Fang et al., 2017). Additionally, socioeconomic factors, such as lower income levels and reduced access to transportation, exacerbate these challenges, creating further inequities in CR utilization (Suaya et al., 2007).

Healthcare system-related barriers also play an important role. Evidence indicates that women are less likely to be referred to CR due to implicit physician biases and a lack of education about CR benefits for female patients (Missik, 2001; Mochari et al., 2006). Physicians may underestimate the potential benefits of CR for women or assume lower levels of adherence, which perpetuates disparities (Missik, 2001; Mochari et al., 2006). Structural barriers within CR programs, such as rigid scheduling and limited program availability during convenient hours, further restrict women's participation (Supervía et al., 2017). Addressing these barriers requires an understanding of how both sex and gender intersect to influence CR utilization. While strategies like flexible scheduling, and hybrid or home-based CR models, and improved physician education can help to mitigate these challenges, targeted efforts to address systemic inequities and implicit biases are essential for achieving gender equity in CR.

Ethnicity. Ethnicity independently influences referral, enrollment, and completion of CR (Castellanos et al., 2019; Mochari et al., 2006; Prince et al., 2014; Ritchey et al., 2020). For instance, Prince et al. (2014) observed that 54.4% of referred ethnic minorities enrolled in CR compared to 65.2 % of referred non-Hispanic whites (n = 822; 51.5% non-Hispanic whites; p = 0.003). A large national study reported that only 7.8% of eligible non-white patients utilized CR

(Suaya et al., 2007). Hispanics and non-Hispanic Blacks are 37% and 30% less likely to participate in CR compared with non-Hispanic whites, respectively (Ritchey et al., 2020). Inadequate referral (Gregory et al., 2006; Roblin et al., 2004) and financial barriers (Cooper et al., 1999; Cooper et al., 2002; Mochari et al., 2006; Nielsen et al., 2008; Valencia et al., 2011) are suggested to underpin this ethnic disparity.

Socioeconomic status. Socioeconomic status significantly impacts the use of CR (Ades et al., 1992; Castellanos et al., 2019; Shanmugasegaram et al., 2013; Suaya et al., 2007; Valencia et al., 2011). Patients of lower socioeconomic status have significantly lower referral, enrollment, and participation rates compared to patients of higher socioeconomic status (Ades et al., 1992; Allen et al., 2004; Benjamin et al., 2017; Castellanos et al., 2019; Shanmugasegaram et al., 2013; Suaya et al., 2007). Factors such as income, insurance status, educational background, and cost of services are the primary determinants of CR utilization, making socioeconomic status a strong predictor (Castellanos et al., 2019).

Place of residence. Geospatial barriers—including program location, distribution, distance, and travel time—predict referral, enrollment, and completion rates (Cooper et al., 2002; Grace, Gravely-Witte, et al., 2008; King et al., 2001; Leung et al., 2010). Increase travel times and rural residency are negatively associated with referral and enrollment, though these factors appear not to influence program completion. Specifically, patients are less likely to enroll when drive times exceed 60 minutes or distances exceed 20 kilometres (Brual et al., 2010; Grace, Gravely-Witte, et al., 2008; Higgins et al., 2008; Suaya et al., 2007). However, adherence among those who enroll is not related to drive time (Brual et al., 2010). Additionally, lack of transportation access has been reported as significant barrier (Grace, Gravely-Witte, et al., 2008;

Harrison & Wardle, 2005). Geospatial barriers are important, as rural cardiovascular patients have demonstrated higher negative mortality outcomes (Valencia et al., 2011).

Medical-Related Factors. *Comorbidities.* Patients with multiple comorbidities have the highest eligibility rates for CR but the lowest utilization rates (Ritchey et al., 2020). This represents a missed opportunity, as these patients may benefit the most from comprehensive rehabilitation programs. Policymakers should consider targeting individuals at the highest risk for secondary cardiovascular events based on their risk factor profiles, potentially enhancing the cost effectiveness of rehabilitation programs.

Medical Indications. The qualifying event for CR (e.g., acute myocardial infarction, percutaneous coronary intervention, coronary artery bypass graft) influences referral, enrollment, and completion (Ritchey et al., 2020; Shanmugasegaram et al., 2013). Patients undergoing a cardiovascular procedure are eight times more likely to participate than those hospitalized for a event without a procedure (Ritchey et al., 2020). Additionally, patients who have undergone coronary artery bypass grafting experience fewer barriers compared to those with other indications (Higgins et al., 2008; Shanmugasegaram et al., 2013; Suaya et al., 2007). This may be because both patients and physicians place more importance on rehabilitation following surgical interventions (Suaya et al., 2007).

Health System Related Barriers. *Wait-time*. Wait-time—the period from an initial acute cardiovascular event to formal entry into a rehabilitation program—is a key barrier to referral and enrollment (Dafoe et al., 2006; Parker et al., 2011; Swabey et al., 2004). The Canadian Cardiovascular Society recommends a wait-time of 1 to 30 days depending on disease severity, with an acceptable range of 7 to 60 days (Dafoe et al., 2006). However, the Ontario Cardiac Rehabilitation Pilot Project reported average and median wait times of 99 and 70 days, respectively, with only a 15% to 30% enrollment rate (Swabey et al., 2004). In contrast, early cardiac access clinics in Alberta reduced wait-times to 4 to 14 days, resulting in 100% referral, 87.8% enrollment, and over 70% completion rates (Parker et al., 2011). These findings highlight that timely access is a significant determinant of CR utilization.

Funding. Healthcare funding critically affects access to CR, yet literature on program funding is sparse. Despite the cost-effectiveness of CR (Ades et al., 1997; Alter et al., 2017; Moghei et al., 2017; Oldridge et al., 2016; Wong et al., 2012), funding and human resource limitations hinder the necessary expansion of services. Lower-cost options—such as home-based programs, hybrid models (e.g., satellite centres and/or tele-health), shorter CR programs, and using lower-cost equipment—can help address funding challenges (Moghei et al., 2017).

Physician-Related Barriers. Physician endorsement is the most commonly citied reason for inadequate referral and enrollment, according to both researchers and patients (Ades et al., 1992; Clark et al., 2013; Daly et al., 2002; Grace et al., 2002; Grace, Gravely-Witte, et al., 2008; Grace, Grewal, et al., 2008; Jackson et al., 2005; Pasquali et al., 2001). Evidence shows physician-related bias result in differential referral rates among stigmatized groups (Blair et al., 2013). Implementing systematic referral processes can eliminate such biases, particularly among diverse ethnic groups, and simultaneously increase referral and completion rates (Grace, Angevaare, et al., 2012; LaBresh et al., 2004; Meillier et al., 2012). Factors influencing physician endorsement include lack of physician knowledge of CR program locations, absence of standardized referral forms across programs, inconvenience of completing referrals, perceptions of poor program quality (Grace, Grewal, et al., 2008), lack of discharge communication from previously referred patients (Yee et al., 2011), long distances for patients to travel (Brual et al., 2010; Clark et al., 2013), perceptions of low patient motivation, and unclear responsibility within the healthcare team for initiating referrals (Grace et al., 2004).

Psychosocial-Related Barriers. Psychosocial barriers affect patient compliance with CR (Daly et al., 2002). These include self-efficacy, self-motivation, self-esteem, personality, depression, anxiety, subjective social status, and social support (Daly et al., 2002; Grace, Gravely-Witte, et al., 2008). Improved self-efficacy, self-motivation, self-esteem, and social support as well as reduced depression and anxiety results in greater attendance and compliance to completing a CR program (Daly et al., 2002; Young et al., 2020). These barriers are impacted by physician endorsement, being female, being older, having lower education status, and having a poor functional capacity (Brezinka & Kittel, 1996; Daly et al., 2002; Hiatt et al., 1990; Suaya et al., 2007).

2.4.6 Interventions to Increase Referral & Utilization of Cardiac Rehabilitation

A 2010 Position Statement by the Canadian Association of Cardiac Rehabilitation and the Canadian Cardiovascular Society recommends implementing systematic referral strategies combined with bedside discussions to enhance both referral and utilization rates of CR programs (Grace, Chessex, et al., 2011). These strategies directly address barriers such as physician-related biases and insufficient patient education. For instance, systematic referral methods, such as standardize discharge order sets, address physician-related barriers by ensuring consistent referral practices and reducing implicit biases that often lead to under-referral among women and ethnic minorities. Evidence indicates that systematic referral can improve enrollment by 45% compared to usual care practices (Grace, Chessex, et al., 2011).

To overcome barriers associated with patient motivation and lack of education, patient-centered interventions, such as personalized letters, have been shown to increase utilization by 73% (Grace, Chessex, et al., 2011). Combined systematic and liaison-based approaches, which incorporate patient education during hospital stays, result in a 66% increase in utilization; while liaison interventions alone improve utilization by 44% (Grace, Chessex, et al., 2011).

Healthcare system barriers, such as lengthy wait times and limited program availability, can discourage participation. Reducing the time gap between discharge and CR initiation is particularly effective for patients of lower socioeconomic status and those with greater travel distances to CR centers. Early cardiac access clinics, which reduce wait times to 4 to 14 days, have achieved referral and completion rates of 100% and 74.4%, respectively, compared to 55.8% and 29.9% with usual care (Parker et al., 2011).

Hybrid and home-based CR models also address barriers linked to age, socioeconomic status, and geographic location by offering flexibility in scheduling and reducing the need for long travel distances. These approaches are particularly beneficial for younger patients balancing work and caregiving responsibilities, as well as older adults with mobility issues or functional limitations (Anderson et al., 2016; Harrison et al., 2015).

Sociodemographic barriers, including sex and ethnicity, are addressed by interventions that actively engage patients and reduce disparities. For example, frontline nurses who provide individualized education during hospitalization and facilitate referrals have increased CR participation by 27% (Santiago de Araújo Pio et al., 2019). Additionally, peer navigation programs, where former CR participants mentor new patients, help overcome psychosocial barriers by improving motivation and self-efficacy (Scott et al., 2013).

Place of residence and transportation challenges can also be mitigated through coordinated discharge planning, home visits, and telephone follow-ups (Carroll et al., 2007; Cossette et al., 2012). These interventions ensure that patients residing in rural areas or lacking transportation are not excluded from CR participation.

To address adherence barriers, gender-tailored programs that accommodate women's caregiving roles and socioeconomic constraints have been effective, improving adherence and completion rates (Beckie & Beckstead, 2010). Shorter program durations and unsupervised rehabilitation options also reduce scheduling conflicts for younger patients and those with demanding work schedules (Hwang et al., 2017; Kraal et al., 2014). Cognitive-behavioral therapy interventions, whether delivered in groups or individually, target psychosocial barriers such as anxiety, depression, and low self-efficacy (Focht et al., 2004; Lynggaard et al., 2017). These strategies not only enhance motivation but also equip patients with coping mechanisms to sustain participation. Finally, smartphone-based interventions that utilize apps and text messaging reminders have shown promise in addressing logistical and psychosocial barriers by increasing flexibility, providing encouragement, and promoting accountability (Varnfield et al., 2014). By addressing the specific barriers to CR referral, enrollment, adherence, and completion through these targeted interventions, healthcare providers and policymakers can improve participation rates and ultimately enhance patient outcomes, reducing rehospitalizations, and decrease mortality associated with cardiovascular disease.

Chapter 3: Conceptual Framework & Methods

3.1 Conceptual Framework

This study is guided by Andersen's Behavioural Model of Health Services Use (Andersen, 1995), which explores how individual and contextual characteristics facilitate or impede healthcare utilization. This model is well-suited for examining CR participation, as it encompasses various factors that influence referral, enrollment, and completion, allowing for a deeper understanding of CR usage.

Andersen's model categorizes factors into predisposing, enabling resources, and need factors, which are essential in understanding CR stages (referral, enrollment, and completion) and how patients interact with healthcare services at each step. Predisposing characteristics refer to inherent traits influencing an individual's likelihood of requiring healthcare services before illness occurs, such as demographics, social structures, and psychological factors. In this study, predisposing factors include age, sex, and ethnicity. Enabling resources are factors that enable healthcare access, such as the availability of healthcare services, transportation, income, education, and social support. In this study, enabling resources are represented by neighborhood income, educational attainment, and place of residence. According to Anderson, individuals with more enabling resources are more likely to access healthcare, which helps differentiate between equitable access (determined by predisposing and need factors) and inequitable access (driven by factors like income and ethnicity). Need factors are the most immediate reasons for seeking healthcare services, as perceived by the individual or evaluated by a professional (Andersen, 1995). In this study, the need factor is defined by the index event that led to CR eligibility. These index events include acute myocardial infraction, angina, or heart failure.

The efficacy of CR is typically assessed through outcomes such as time to rehospitalization and mortality, as opposed to less severe outcomes in other health services.

Anderson's model suggests that serious outcomes (e.g., rehospitalization, mortality) are more likely to be explained by predisposing and need factors, while less severe services are influences by enabling resources. Figure 3.1 presents the adapted conceptual framework for this study.

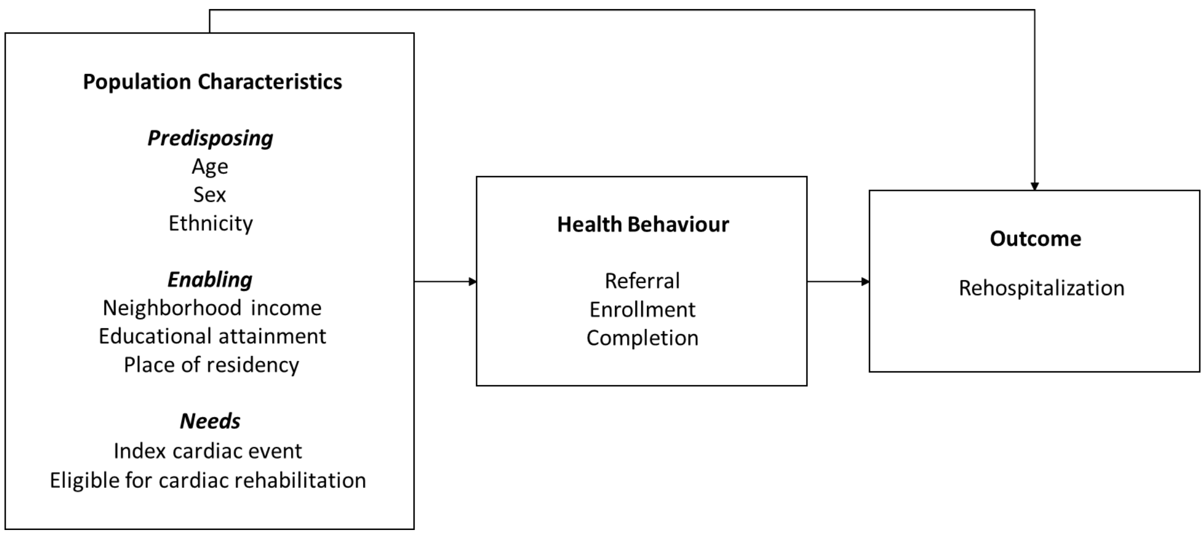

Figure 3.1 Conceptual framework of the current study, inspired by Anderson's Behavioural Model of Health Services Use (1995).

3.2 Hypotheses & Research Questions

Referral, Enrollment, & Completion. What proportion of eligible patients are referred, enrolled, and complete CR in the TBRHSC catchment area, and how do predisposing, enabling, and need factors influence these stages of CR? We hypothesize age, sex, income, education, and place of residency will significantly influence CR utilization, as these factors have been demonstrated to be the most relevant within the existing literature.

Impact on Rehospitalization. How does completing CR impact time to cardiac-related rehospitalization, accounting for predisposing, enabling, and need factors? We hypothesize completing CR will delay rehospitalization after accounting for factors such as age, sex, income, education, and place of residency.

3.3 Methods

Study Design. This study employs a retrospective cohort design, utilizing electronic health records from the TBRHSC to address the research questions.

3.3.1 Study Settings

Canada's universal health system ensures access to essential medical services for all residents without financial barriers (Canada Health Act, 1984). However, access to secondary prevention services like CR is often limited by program capacity and human resources. Nationally, fewer than 50% of eligible cardiac patients participate in CR programs, with participation rates as low as 30% in Ontario (Candido et al., 2011; Grace et al., 2014). Within the NWLHIN, participation rates are even lower, estimated at approximately 23.6%, highlighting significant disparities in access compared to both provincial and national levels (Candido et al., 2011).

This study focuses on Thunder Bay, Ontario, and the TBRHSC catchment area, which encompasses the Thunder Bay District and Northwestern Health Units. This region is part of the NWLHIN, representing a geographically vast area with a population of 222,085 as per the 2011 Census (Statistics Canada, 2012). Northwestern Ontario is characterized by its diversity and uniqueness, including a mix of urban, rural, and remote Indigenous communities. Approximately 13% of the region's population identify as Indigenous, compared to 3% in the overall Canadian population, reflecting the highest proportion of Indigenous residents among all the LHINs in Ontario (Statistics Canada, 2017). The region's remote geography often necessitates significant travel for healthcare access, with some patients residing over 1,000 kilometres from the nearest specialized cardiac services, further compounding disparities in access to CR.

TBRHSC is the primary acute care hospital in the region, serving as a referral center for patients from across Northwestern Ontario. In 2006-2007, TBRHSC reported an average of 3,863 cardiac hospitalizations annually, with 1,537 patients identified as eligible for CR (Candido et al., 2011). Despite systematic referral processes being implemented at TBRHSC, the region's only CR program has the capacity to treat only 363 patients per year, meeting the needs of just 23.6% of eligible patients (Candido et al., 2011). This contrast highlights the challenges of delivering CR services in this geographically isolated and resource-limited region.

The TBRHSC CR program, established in 2007 and situated near the main hospital, adheres to the Standards for the Provision of Cardiac Rehabilitation in Ontario (Cardiac Care Network of Ontario, 2014). Healthcare professionals at the TBRHSC employ a systematic referral process, recording CR referrals on patient discharge forms during hospital admission and before discharge, ensuring that eligible patients are referred to the program.

3.3.2 Study Population & Eligibility Criteria

The study population includes all patients diagnosed with ischemic heart disease and discharged from the TBRHSC between July 14th, 2014 and December 31st, 2017, and who reside within the TBRHSC catchment area. Eligible patients were followed until February 28th, 2023, providing a range of approximately 5 to 9 years of follow-up. Eligibility aligns with the TBRHSC CR program inclusion criteria based on the Standards for the Provision of Cardiovascular Rehabilitation (2014). Therefore, patients 18 years of age and older who were discharged with a diagnosis of ischemic heart disease, including acute myocardial infarction, angina, or heart failure were included. Additionally, patients must have been referred to CR within one year of the index cardiac-related event to ensure that the data reflects their initial presentation to the rehabilitation program. Patients were excluded if they had an unstable cardiac condition, orthopedic, neuromuscular, cognitive, psychiatric condition(s), or vision impairments, were a high falls risk, had previously completed CR, or were not residents within the TBRHSC catchment area. Furthermore, patients who died or were rehospitalized within 6 months of the index event were excluded from the study.

3.3.3 Data Sources

The primary investigator extracted data on patient demographics, medical history, clinical details, and healthcare services accessed, using electronic medical records from both the hospital and CR program. Collected information included patient demographic characteristics (e.g., age, sex, marital status, and postal code), the primary diagnosis for referral to CR, and details of the index event, such as admission and discharge dates, hospital length of stay, and physical activity level assessed by the Duke Activity Status Index. The history of comorbidities preceding the index event was also recorded. The International Classification of Diseases 10th Edition (ICD-10) codes was used to determine the primary diagnosis for the index cardiac event (refer to Appendix A, Table A1 for a detail breakdown of eligible ICD-10 codes). For example, acute myocardial infarction is identified by ICD-10 codes I21 and I22. Drive time and distance to the TBRHSC CR program will be determined through access to postal codes and mapped using Google Maps.

Since hospital and CR data do not include individual-level socioeconomic status, area-level data from the Ontario Marginalization Index (ON-Marg) were used as a valid proxy (Matheson & van Ingen, 2018). Two ON-Marg dimensions were utilized: (1) material resources, which assesses income and educational attainment, and (2) racialized & newcomer populations, which reflects concentrations of recent immigrants and/or people belonging to visible minority groups (excluding Indigenous peoples who are non-Caucasian in race or non-white in colour). Both dimensions were assessed at the dissemination area level, the smallest geographic unit using census data, and reported using a quintile scale (where 5 represents the lowest resources or highest ethnic concentration). To obtain these variables, patient postal codes were linked to corresponding dissemination areas using Google Maps and the ON-Marg Index Interactive Map.

3.3.4 Study Variables

Exposure & Outcome Assessment

***Objective 1*: This objective addresses the research question: *What proportion of eligible patients within Northwest Ontario are referred to, enroll in, and complete CR, and how do sociodemographic and geographical factors affect these stages?* It focuses on identifying the predisposing, enabling, and needs factors that influence CR participation among eligible patients. The primary outcomes examined are referral to CR within 12 months of their index event, enrollment in the program, and completion of CR.

***Objective 2*: This objective addresses the research question: *Does completing CR influence time to rehospitalization, after controlling for sociodemographic and geographical factors?* It evaluates the impact of CR completion, defined as attending at least 70% of exercise sessions (Alter et al., 2009, 2017; Hammill et al., 2010), on time to rehospitalization. The primary outcome is the number of days from hospital discharge after the index event to rehospitalization at TBRHSC for a subsequent cardiac event. Patients who died, experienced rehospitalization, or remained alive without rehospitalization by the end of February 2023 are censored.

3.3.5 Covariate Assessment

This study assessed a range of covariates to understand their impact on the primary outcomes—with the primary outcomes being referral to CR within 12 months of the index event, enrollment in CR, and completion of CR, as well as the secondary outcome, time to cardiac-related rehospitalization. These covariates were selected based on their relevance to CR participation and outcomes, as outlined in Appendix A, Table A2.

Continuous covariates include age, drive time, and distance to CR services, while categorical covariates include sex, racialized and newcomer population status, material resources, pre-existing comorbidities, previous cardiac procedures, most responsible diagnosis, rural residency, partner status, Duke Activity Status Index, and relevant risk factors such as hypertension, hyperlipidemia, and smoking status.

In this study, patients living within the city limits of Thunder Bay were categorized as urban, while those residing outside the city limits were categorized as rural. However, this classification excludes patients who attended satellite CR programs located in other communities outside of Thunder Bay. As a result, these individuals were not included in either group, potentially influencing the applicability of the term “rural” to this population. While the term “rural” generally reflects geographic isolation and limited healthcare access, it may not fully capture the diversity of living environments for patients outside Thunder Bay in this study. For clarity, rural residency here specifically refers to individuals living outside the city limits of Thunder Bay but does not include those accessing CR in satellite locations.

While these covariates provide a comprehensive view of patient characteristics, they are not exhaustive. For instance, other potentially influential factors, such as social support or access to telehealth services, could not be assessed due to data limitations. The selection of covariates was determined by the data availability, which inherently limits the scope of the variables analyzed in this study.

3.4 Statistical Analyses

Descriptive analyses were performed to characterize the study population, including counts and percentages for categorical variables and means and standard deviation for continuous variables. Bivariate analyses were conducted using binary logistic regression to examine the associations between covariates (e.g., sex, age, comorbidities) and each stage of CR, including referral, enrollment, and completion.

For the multivariate analyses, we employed binary logistic regression to determine which covariates were independently associated with the likelihood of patients progressing through each stage of CR participation. Each stage—such as referral, enrollment, attendance, and completion—was treated as a separate binary outcome variable in the regression models. Covariates included in the multivariate models were selected based on a combination of statistical significance from the bivariate analyses and the theoretical relevance informed by our conceptual framework. Specifically, even if certain covariates did not reach statistical significance in the bivariate analyses, they were included in the multivariate models if prior research or theoretical considerations indicated their potential importance in influencing CR participation.

In the time-to-event analyses, Kaplan-Meier survival curves were plotted to assess time to cardiac-related rehospitalization, starting from discharge following the index cardiac-related hospitalization. The log-rank test was used to compare survival distribution between groups. Cox proportional hazards regression was used to evaluate the association between CR completion and time to rehospitalization. The Cox model was adjusted for relevant covariates such as sociodemographic factors (e.g., sex, age, ethnicity, socioeconomic status), geographic variables (e.g., drive time, distance), and clinical characteristics (e.g., comorbidities, cardiac procedure). As with the logistic regression models, covariate selection for the Cox models was guided by both statistical findings and theoretical considerations.

Linearity was assessed for continuous covariates in the binary logistic regression analyses using the Box-Tidwell test. The relationship between age (as a continuous variable) and the log-odds of enrollment and completion showed no evidence of non-linearity. Similarly, in the Cox proportional hazards model, linearity between age and the outcomes was evaluated using Martingale residuals, which revealed no significant deviations from linearity. To confirm the robustness of our findings, age was also categorized into four groups (younger adults: 18-49 years, middle-aged adults: 50-64 years, older adults: 65-74 years, and elderly: 75+ years) based on commonly used cut-offs in cardiovascular research and clinical practice. The findings remained consistent across both the continuous and categorical modeling, supporting the decision to retain age as a continuous variable for simplicity and interpretability. Model fit was evaluated using the Hosmer-Lemeshow test for binary logistic regression and log-likelihood tests for the Cox proportional hazards regression. All analyses were conducted using SPSS version 26.0 for Windows (IBM, Armonk, NY, USA) and the statistical significance level was set at 0.05.

Chapter 4: Findings

4.1 Characteristics of the Study Population

A total of 968 cases were identified as having an index cardiac event that was eligible for CR at the TBRHSC during the period of July 8th, 2014 to December 31st, 2017. Of these cases, 521 were excluded: 447 patients resided outside the City of Thunder Bay and nearby municipalities and likewise their electronic medical record was inaccessible; 9 were discharged to hospice; 13 previously completed CR; 17 died during their index cardiac-related hospitalization; and 35 were excluded for various other reasons (e.g., fall risk, significant cognitive impairment, unknown status). The final sample population included 448 patients. The mean age and standard deviation of the patients included in the study was 66 ± 12 years, and the majority were male (68.8%).

Table 4.1 Baseline characteristics of the study population (N = 448).

Variables		Overall N (%)
Predisposing factors		
Age (years), mean (SD)		66 (12)
Sex		
	Male	308 (68.8%)
	Female	140 (31.3%)
Racialized & newcomer populations[1]		n = 444
	Lowest concentration	194 (43.3%)
	Low concentration	180 (40.2%)
	Moderate concentration	56 (12.5%)
	High concentration	13 (2.9%)
	Highest concentration	1 (0.2%)
History before the index CVD event		
# of pre-existing CVD conditions		
	0 – 2 conditions	296 (66.1%)
	+ 3 conditions	152 (33.9%)
# of pre-existing non-CVD conditions		
	0 – 2 conditions	412 (92.0%)
	+ 3 conditions	36 (8.0%)
Pre-existing conditions		
	Renal disease	39 (8.7%)
	On dialysis	5 (1.1%)
	Congestive heart failure	41 (9.2%)

Peripheral vascular disease	38 (8.5%)
Aneurysm	15 (3.3%)
Endocarditis	2 (0.4%)
Valvular heart disease	76 (17.0%)
Cerebrovascular disease	44 (9.8%)
Pulmonary disease	60 (13.4%)
Liver disease	13 (2.9%)
Gastrointestinal disease	106 (23.7%)
Previous malignancy	58 (12.9%)
Previous myocardial disease	120 (26.8%)
Previous cardiac procedures	
Previous PCI	89 (19.9%)
Previous CABG	54 (12.1%)
Previous valve repair/replacement	5 (1.1%)
Previous pacemaker	8 (1.8%)
Enabling factors	
With partner	283 (63.2%)
Material resources[1]	n = 444
Highest resources	75 (16.7%)
High resources	58 (12.9%)
Moderate resources	86 (19.2%)
Low resources	89 (19.9%)
Lowest resources	136 (30.4%)
Geographic	
Distance (km), mean (SD)	9.5 (11.4)
Drive time (min), mean (SD)	11.5 (8.4)
Rural residency	71 (15.8%)
Needs factors	
Most responsible diagnosis	
NSTEMI	230 (51.3%)
STEMI	135 (30.1%)
CHF	11 (2.5%)
Angina	72 (16.1%)
Risk factors	
Hypertension	341 (76.1%)
Hyperlipidemia	254 (56.7%)
Family history of CVD	181 (40.4%)
Current or former smoker	246 (54.9%)
Diabetes mellitus	149 (33.3%)
BMI ≥ 30	159 (35.5%)

Notes
Abbreviations: BMI, body mass index; CABG, coronary artery bypass grafting; CI, confidence interval; CR, cardiac rehabilitation; CVD, cardiovascular disease; NSTEMI, non-ST-elevation myocardial infarction; OR, odds ratio; PCI, percutaneous coronary intervention; STEMI, ST-elevation myocardial infarction.

[1]The Ontario Marginalization Index censor's data with very small populations or where privacy could be compromised. As a result, some cases (n = 4) are censored to protect the confidentiality of cases in those areas.

4.2 Referral, Enrollment, & Completion Rates

Out of the 448 eligible patients, 417 (93.1%) were referred to CR. Those not referred were n = 31 (or 6.9% of the eligible study population). Of the referred patients, 215 (51.7%) enrolled in CR, and 90 (41.9%) of those who enrolled, completed the program. Likewise, of all the patients that were eligible for the study, 19.9% completed CR.

4.2.1 Factors Impacting Enrollment

No factors were associated with the referral of patients to the TBRHSC CR program, as referrals were automatically made during the index cardiac hospitalization. A total of 35 potential covariates were identified as potentially influencing CR enrollment based on the conceptual framework, with 15 selected for the final model analysis. These 15 covariates were based on either statistically significant differences in our bivariate analysis or prior literature supporting their relevance for CR enrollment. Table 4.2 presents the bivariate analysis results for the covariates deemed relevant, while Appendix B, Table B1, depicts the results for all potential covariates considered.

Table 4.2 Bivariate analysis of select covariates thought to impact enrollment in CR with ORs (N = 416, unless otherwise indicated).

Variable	Total N	Enrolled N (%)	OR (95% CI)	p value
Predisposing factors				
Age of enrollees [n = 215], mean (SD)	416	65 (11)	0.98 (0.96-1.00)	0.02
Sex	416			
Male	283	139 (49.1%)	reference	
Female	133	76 (57.1%)	1.38 (0.91-2.09)	0.13
Racialized & newcomer populations[1]	412			0.78 (overall)
Lowest concentration	182	92 (50.5%)	reference	
Low concentration	167	91 (54.5%)	1.17 (0.77-1.78)	0.46
Moderate concentration	51	26 (51.0%)	1.02 (0.55-1.89)	0.96
High concentration	12	5 (41.7%)	0.70 (0.21-2.28)	0.55

Highest concentration	0	0	n/a	n/a
History before the index CVD event				
# of pre-existing CVD conditions	416			
0 – 2 conditions	281	167 (59.4%)	reference	
+ 3 conditions	135	48 (35.6%)	0.38 (0.25-0.58)	< 0.01
# of pre-existing non-CVD conditions	416			
0 – 2 conditions	387	205 (53.0%)	reference	
+ 3 conditions	29	10 (34.5%)	0.47 (0.21-1.03)	0.06
Pre-existing conditions				
Renal disease	30	11 (36.7%)	0.52 (0.24-1.11)	0.09
Congestive heart failure	33	12 (36.4%)	0.51 (0.24-1.06)	0.07
Valvular heart disease	66	24 (36.4%)	0.48 (0.28-0.82)	< 0.01
Cerebrovascular disease	41	15 (36.6%)	0.51 (0.26-0.98)	0.05
Previous myocardial disease	101	36 (35.6%)	0.42 (0.27-0.67)	< 0.01
Previous cardiac procedures				
Previous PCI	77	26 (33.8%)	0.41 (0.24-0.68)	< 0.01
Previous CABG	43	10 (23.3%)	0.25 (0.12-0.52)	< 0.01
Enabling factors				
With partner	416			
No	152	55 (36.2%)	reference	
Yes	264	160 (60.6%)	2.73 (1.80-4.14)	< 0.01
Material resources[1]	412			0.12 (overall)
Highest resources	70	44 (62.9%)	reference	
High resources	52	27 (51.9%)	0.64 (0.31-1.32)	0.23
Moderate resources	80	46 (57.5%)	0.80 (0.41-1.54)	0.50
Low resources	83	40 (48.2%)	0.55 (0.29-1.05)	0.07
Lowest resources	127	57 (44.9%)	0.48 (0.27-0.88)	0.02
Drive time (min), mean (SD)	416			
Not enrolled (n = 201)		12.3 (10.4)		
Enrolled (n = 215)		10.9 (6.4)		
Drive time (per minute increase)			0.98 (0.96-1.00)	0.10
Needs factors				
Most responsible diagnosis	416			0.08 (overall)
NSTEMI	215	100 (46.5%)	reference	
STEMI	128	77 (60.2%)	1.74 (1.11-2.71)	0.02
Congestive heart failure	8	3 (37.5%)	0.69 (0.16-2.96)	0.62
Angina	65	35 (53.8%)	1.34 (0.77-2.34)	0.30

Notes:
Abbreviations: CABG, coronary artery bypass grafting; CI, confidence interval; CR, cardiac rehabilitation; CVD, cardiovascular disease; NSTEMI, non-ST-elevation myocardial infarction; OR, odds ratio; PCI, percutaneous coronary intervention; STEMI, ST-elevation myocardial infarction.
Continuous variables: For age, the mean and SD are presented for the enrolled only. For drive time, the mean and SD are presented for the enrolled and not enrolled groups. The OR represents the change in odds of enrollment per unit increase in the variable.

Categorical variables: Total N represents the total number of patients with the characteristic. Enrolled N (%) is the number and percentage of patients with the characteristic who enrolled in CR. Reference categories are used for calculating ORs in the binary logistic regression. Overall p values are provided for variables with multiple categories, indicating the significance of the variable in the binary logistic regression model.
[1]The Ontario Marginalization Index censor's data with very small populations or where privacy could be compromised. As a result, some cases (n = 4) are censored to protect the confidentiality of cases in those areas.

The adjusted binary logistic regression analysis (Table 4.3) demonstrated that the overall model was significant ($\chi^2 = 80.63$, df = 23, $p < 0.01$), highlighting several covariates impacting CR enrollment, including being female, having a partner, and drive time. Females were more than twice as likely to enroll in CR compared to males ($p < 0.01$). Having a partner was the most significant factor for enrollment, with partnered individuals being over three times more likely to enroll ($p < 0.01$). Additionally, for every additional minute of drive time to the TBRHSC CR program, the likelihood of enrollment decreased by 3% ($p = 0.03$).

Table 4.3 Multivariable binary logistic regression results: OR for covariates impacting CR enrollment.

Variable	OR (95% CI)	p value
Predisposing factors		
Age (per year increase)	0.99 (0.97-1.01)	0.34
Being female (versus male)	2.06 (1.23-3.43)	< 0.01
Racialized & newcomer populations		0.69 (overall)
Lowest concentration	reference	
Low concentration	1.31 (0.79-2.18)	0.29
Moderate concentration	1.47 (0.68-3.17)	0.33
High concentration	1.23 (0.31-4.95)	0.77
Highest concentration	n/a	n/a
History before the index CVD event		
# of pre-existing CVD conditions		
0 – 2 conditions	reference	
+ 3 conditions	0.62 (0.29-1.30)	0.20
# of pre-existing non-CVD conditions		
0 – 2 conditions	reference	
+ 3 conditions	0.73 (0.29-1.85)	0.51
Individual pre-existing conditions		
Renal disease	0.70 (0.29-1.72)	0.44
Congestive heart failure	1.37 (0.54-3.47)	0.51

Valvular heart disease	0.65 (0.32-1.32)	0.23
Cerebrovascular disease	0.79 (0.35-1.80)	0.58
Previous myocardial disease	1.01 (0.43-2.40)	0.98
Previous PCI	0.63 (0.29-1.36)	0.24
Previous CABG	0.43 (0.17-1.06)	0.07
Enabling factors		
With partner (versus no partner)	3.14 (1.92-5.12)	< 0.01
Material resources		0.31 (overall)
Highest resources	reference	
High resources	0.75 (0.33-1.70)	0.49
Moderate resources	0.80 (0.38-1.68)	0.55
Low resources	0.59 (0.28-1.24)	0.16
Lowest resources	0.48 (0.24-0.97)	0.04
Drive time (per minute increase)	0.97 (0.94-1.00)	0.03
Needs factors		
Most responsible diagnosis		0.42 (overall)
NSTEMI	reference	
STEMI	1.51 (0.90-2.53)	0.12
Congestive heart failure	0.86 (0.13-5.54)	0.88
Angina	1.37 (0.74-2.55)	0.32

Notes
Abbreviations: CABG, coronary artery bypass grafting; CI, confidence interval; CR, cardiac rehabilitation; CVD, cardiovascular disease; NSTEMI, non-ST-elevation myocardial infarction; OR, odds ratio; PCI, percutaneous coronary intervention; STEMI, ST-elevation myocardial infarction.

4.2.2 Factors Impacting Completion

A total of 36 potential covariates were identified as potentially impacting CR completion, with 12 selected for the final model analysis. The covariates chosen were similar to those of enrollment but wait time and physical activity level were added as covariates potentially influencing CR completion (Table 4.4). Appendix B, Table B2, provides a full list for the bivariate analysis of potential covariates for CR completion.

Table 4.4 Bivariate analysis of select covariates thought to be associated with completion of CR with ORs (N = 215).

Variables	Total N	Completed N (%)	OR (95% CI)	p value
Predisposing factors				
Age of those who completed CR [n = 90], mean (SD)	215	65 (12)	1.00 (0.98-1.03)	0.80
Sex	215			

Male	139	66 (47.5%)	reference	
Female	76	28 (36.8%)	0.65 (0.36-1.14)	0.13
Racialized & newcomer populations[1]	214			0.56 (overall)
Lowest concentration	92	36 (39.1%)	reference	
Low concentration	91	42 (46.2%)	1.33 (0.74-2.40)	0.34
Moderate concentration	26	11 (42.3%)	1.14 (0.47-2.76)	0.77
High concentration	5	1 (20.0%)	0.39 (0.04-3.62)	0.41
Highest concentration	0	0	n/a	n/a
History before the index CVD event				
Pre-existing conditions	215			
Congestive heart failure	33	2 (6.1%)	0.26 (0.06-1.22)	0.09
Pulmonary disease	23	5 (21.7%)	0.35 (0.13-0.98)	0.05
Enabling factors				
With partner	215			
No	55	22 (40.0%)	reference	
Yes	160	68 (42.5%)	1.12 (0.60-2.11)	0.72
Material resources[1]	214			0.13 (overall)
Highest resources	44	20 (45.5%)	reference	
High resources	27	16 (59.3%)	1.75 (0.66-4.60)	0.26
Moderate resources	46	20 (43.5%)	0.92 (0.40-2.12)	0.85
Low resources	40	17 (42.5%)	0.89 (0.37-2.10)	0.79
Lowest resources	57	17 (29.8%)	0.51 (0.22-1.16)	0.11
Drive time (min), mean (SD)	215			
Did not complete (n = 125)		11.1 (6.4)		
Completed (n = 90)		10.6 (6.4)		
Drive time (per minute increase)			0.99 (0.95-1.03)	0.59
Wait-time (days)[2]	212			
≤ 90 days	147	64 (43.5%)	reference	
> 90 days	65	25 (38.5%)	0.81 (0.45-1.47)	0.49
Needs factors				
Duke activity status index[2]	203			0.01 (overall)
Low	56	15 (26.8%)	reference	
Moderate	118	59 (50.0%)	2.73 (1.37-5.47)	< 0.01
High	29	11 (37.9%)	1.67 (0.64-4.34)	0.29
Risk factors	215			
Family history of CVD	91	46 (50.5%)	1.86 (1.07-3.23)	0.03
Current or former smoker	117	42 (35.9%)	0.58 (0.34-1.01)	0.05

Notes

Abbreviations: CABG, coronary artery bypass grafting; CI, confidence interval; CR, cardiac rehabilitation; CVD, cardiovascular disease; NSTEMI, non-ST-elevation myocardial infarction; OR, odds ratio; PCI, percutaneous coronary intervention; STEMI, ST-elevation myocardial infarction.

Continuous variables: For age and drive time, the mean and SD are presented for the did not complete and completed groups. The OR represents the change in odds of completion per unit increase in the variable.

Categorical variables: Total N represents the total number of patients with the characteristic. Completed N (%) is the number and percentage of patients with the characteristic who completed in CR. Reference categories are used

for calculating ORs in the binary logistic regression. Overall p values are provided for variables with multiple categories, indicating the significance of the variable in the binary logistic regression model.
[1]The Ontario Marginalization Index censor's data with very small populations or where privacy could be compromised. As a result, some cases (n = 1) are censored to protect the confidentiality of cases in those areas.
[2]Reduce sample size due to data entry errors or omissions.

The adjusted binary logistic regression analysis for CR completion (Table 4.5) demonstrated that the overall model was significant ($\chi^2 = 33.05$, df = 18, p = 0.02). The multivariate binary logistic regression analysis identified having a family history of cardiovascular disease was associated with a significantly higher likelihood of completing CR, with patients nearly twice as likely to complete CR compared to those without a family history [OR = 2.18, 95% CI (1.13-4.22), p = 0.02]. Other variables, including age, sex, congestive heart failure, and drive time, did not significantly impact the likelihood of completing CR (p > 0.05 for all). Similarly, socioeconomic factors such as the ON-Marg Index variables material resources and racialized & newcomer population, as well as smoking status, did not show a significant association with CR completion (p > 0.05 for all) (Table 4.5).

Table 4.5 Multivariable binary logistic regression results: OR for covariates impacting completion of CR.

Variable	OR (95% CI)	p value
Predisposing factors		
Age (per year increase)	1.01 (0.98-1.04)	0.51
Being female (versus male)	0.56 (0.28-1.13)	0.10
Racialized & newcomer populations		0.33 (overall)
Lowest concentration	reference	
Low concentration	1.98 (0.94-4.18)	0.07
Moderate concentration	1.48 (0.47-4.62)	0.51
High concentration	2.69 (0.28-25.69)	0.39
Highest concentration	n/a	n/a
Pre-existing conditions		
Congestive heart failure	0.19 (0.03-1.12)	0.07
Pulmonary disease	0.39 (0.12-1.26)	0.12
Enabling factors		
With partner (versus no partner)	0.57 (0.26-1.25)	0.16

Material resources			0.09 (overall)
	Highest resources	reference	
	High resources	1.55 (0.51-4.74)	0.44
	Moderate resources	1.10 (0.43-2.82)	0.85
	Low resources	1.58 (0.60-4.21)	0.36
	Lowest resources	0.40 (0.15-1.11)	0.08
Drive time (per min increase)		0.98 (0.92-1.04)	0.44
Wait time		0.88 (0.43-1.78)	0.71
Needs factors			
Duke activity status index			0.49 (overall)
	Low	reference	
	Moderate	1.45 (0.67-3.14)	0.35
	High	0.95 (0.32-2.82)	0.93
Risk factors			
	Family history of CVD	2.18 (1.13-4.22)	0.02
	Current or former smoker	0.67 (0.34-1.34)	0.26

Notes
Abbreviations: CI, confidence interval; CVD, cardiovascular disease; OR, odds ratio.

4.2.3 Time to Rehospitalization

We analyzed whether completing CR impacted patients' outcomes, as measured by the time to rehospitalization up to the end of February 2023, following an index cardiac-related event. As such, those who completed CR (n = 96) were compared to those who did not complete CR (n = 295). Those who did not complete CR were considered our non-exposed group and consisted of patients who where not referred to CR, were referred but did not enroll, and enrolled but did not complete CR.

The Kaplan-Meier survival analysis revealed that out of the 391 patients included in the time to rehospitalization analysis, 165 (or 42.5%) experienced rehospitalization following their index cardiac-related event, while 226 (or 57.8%) were censored. Censoring occurred due to patients reaching the study endpoint without a cardiac-related rehospitalization or death. The proportion of censored cases was similar between patients who completed CR (63.5%) and those who did not (55.9%; p = 0.18). Among those who experienced rehospitalization, the average time to rehospitalization was 959 days (95% CI: 857 to 1060 days). This indicates that, on average, patients were rehospitalized approximately 2 years and 7 months after their initial hospitalization. When stratified by CR completion status, patients who completed CR had an average time to rehospitalization of 1,194 days [95% CI (990 to 1,398 days)] compared to those who did not, 893 days [95% CI (779 to 1,008 days), p = 0.05].

The unadjusted survival analysis indicated that completing CR significantly reduces the risk of rehospitalization for a cardiac event [Hazard ratio (HR) = 0.69, 95% CI (0.47-1.00), p = 0.05], indicating that patients who complete CR were rehospitalized 31% less rapidly compared to those who did not complete CR.

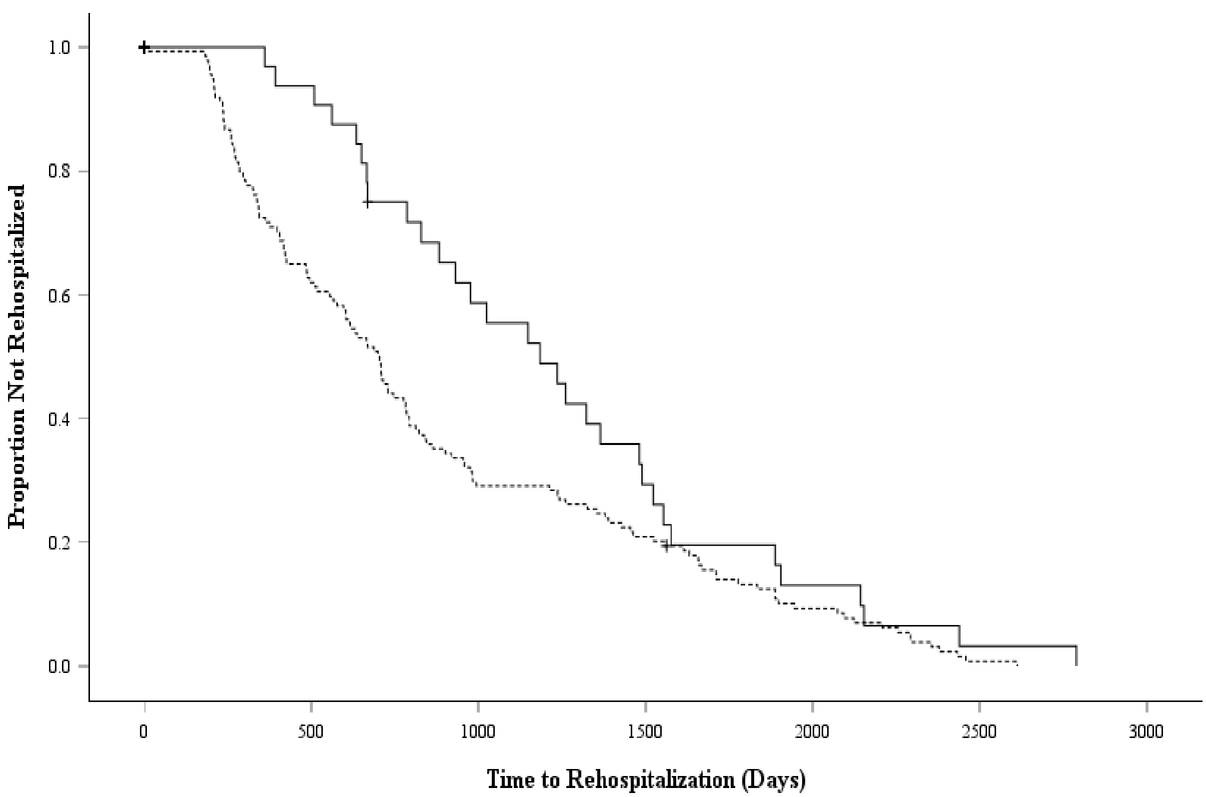

Figure 4.1 Kaplan-Meier survival curve for time to rehospitalization by cardiac rehabilitation (CR) completion status. The solid line represents patients who completed CR, while the dashed line represents patients who did not complete CR. The log-rank test indicated a significant difference between the two groups (p = 0.05).

A multivariable Cox proportional hazards regression was used to adjust for covariates that could either directly impact time to rehospitalization (e.g., pre-existing conditions) or modify the effect of completing CR on this outcome (e.g., enabling factors like having a partner). Covariates were selected based on clinical relevance as described in the literature and statistical significance in our bivariate analyses (Appendix B, Table B3). Covariates selected for the Cox model are shown in Table 4.6. After adjusting for these covariates, completing CR was associated with a 23% reduction in the risk of rehospitalization [HR = 0.77, 95% CI (0.51-1.17)]; though this result did not reach statistical significance ($p = 0.26$).

Table 4.6 HRs and 95% CIs from the adjusted Cox regression analysis of the impact of CR completion on time to rehospitalization.

Variable		HR (95% CI)	p value
Completing CR		0.79 (0.53-1.19)	0.26
Predisposing factors			
Age (per year increase)		1.01 (0.99-1.02)	0.27
Being female (versus male)		0.89 (0.62-1.29)	0.54
# of pre-existing CVD conditions		1.17 (0.76-1.81)	0.47
# of pre-existing non-CVD conditions		1.66 (0.87-2.84)	0.09
Pre-existing conditions			
	Congestive heart failure	0.98 (0.58-1.64)	0.94
	Pulmonary disease	0.85 (0.54-1.35)	0.50
	Previous myocardial disease	0.82 (0.52-1.29)	0.39
Previous cardiac procedures			
	Previous CABG	2.00 (1.24-3.23)	<0.01
Enabling factors			
With partner (versus no partner)		0.88 (0.61-1.26)	0.48
Current or former smoker		1.43 (1.00-2.05)	0.05

Notes:
Abbreviations: CABG, coronary artery bypass grafting; CI, confidence interval; CR, cardiac rehabilitation, CVD, cardiovascular disease; HR, hazard ratio
Covariates were selected based on their potential to either directly impact the outcome of rehospitalization or to modify the effect of completing CR on rehospitalization.

Chapter 5: Discussion

This study is the first to investigate factors influencing referral, enrollment, and completion of CR in the unique and geographically diverse context of Northwest Ontario. Northwest Ontario spans a vast area with a low population density, characterized by significant travel distances, harsh winter weather conditions, and a limited number of healthcare facilities, which may pose challenges to accessing and delivering healthcare services, including CR. This study also examines the impact of CR completion on time to cardiac-related rehospitalization in this region. The study included eligible patients that experienced an index cardiac event within the TBRHSC catchment area, from July 2014 to December 2017, met specific inclusion criteria, and were followed until the end of February 2023. Patients whose electronic medical records required additional ethical approval were excluded, primarily those participating in CR at one of the region's satellite hospitals. Due to time constraints associated with completing the master's program, the decision was made to focus on patients eligible to participate in the TBRHSC CR program.

Of the 448 patients included in this study, 93.1% were referred to CR, 51.7% of referred patients enrolled, and 41.9% of those enrolled completed the program, resulting in an overall completion rate of only 19.9%. While this overall completion rate falls short of the recommendations set by the Canadian Association of Cardiovascular Prevention and Rehabilitation and the Canadian Cardiovascular Society, which suggest that 85% of eligible patients be referred and 70% of those referred should enroll in CR (Grace, Chessex, et al., 2011), the automatic referral process at TBRHSC represents a significant success, achieving referral rates consistent with national recommendations. This achievement highlights the importance of maintaining and expanding automatic referral processes to ensure a high proportion of eligible patients are referred to CR.

National data on CR completion rates are limited (Ades et al., 2017; Beatty et al., 2018; Bethel et al., 2007; Brady et al., 2013; Candido et al., 2011; Martin et al., 2012; Suaya et al., 2007), and very few studies report rates that meet these recommendations (Grace, Angevaare, et al., 2012; Parker et al., 2011). For instance, coverage rates across Ontario were estimated around 34% of eligible patients in 2011 (Candido et al. 2011; Grace et al., 2016) with even lower coverage rates of 23.6% in Northwestern Ontario, which includes the TBRHSC catchment area (Candido et al., 2011). The limited data describing CR participation in the literature along with the low coverage rates found in Ontario highlight the challenges of meeting national targets for CR enrollment and completion.

While the automatic referral process at TBRHSC aligns with national recommendations, only 51.7% of referred patients enrolled in CR, indicating a significant gap in meeting enrollment targets. Recent studies have explored various strategies to enhance CR enrollment and completion rates. For instance, the Early Cardiac Access Clinic (ECAC) model schedules follow-up visits shortly after hospital discharge, providing immediate access to CR orientation and programming. This approach has achieved enrollment and completion rates of 87.8% and 71.4%, respectively (Parker et al., 2011). Additionally, integrating patient education strategies can improve adherence to CR programs. The “Learning and Coping” strategy, which emphasizes inductive teaching and active patient involvement, has been associated with higher adherence rates to educational and physical exercise sessions compared to traditional consultation programs (Brito et al., 2022). Furthermore, systematic tracking of enrollment progress and personalized communication between CR services and patients are also important. A lack of timely and personalized communication has been identified as a barrier to enrollment, suggesting that enhancing these aspects could facilitate better patient engagement (Abdullahi et al., 2022).

Implementing similar strategies at TBRHSC, such as early follow-up clinics, enhanced patient education through the "Learning and Coping" strategy, and systematic tracking of enrollment progress with personalized communication, could help bridge the gap in CR enrollment and improve patient outcomes in this region.

5.1 Factors Affecting the Referral, Enrollment, & Completion of CR

In our study, while a higher proportion of males were referred to CR, this reflects their greater representation in the study population rather than a higher referral rate among men. Historically, females have been referred to CR less frequently than males, contributing to gender disparities in access to CR. The automatic referral process likely contributed to equitable referral rates across genders in our study, aligning with national recommendations and addressing this previously observed inequity (Grace et al., 2016; Peters & Keeley, 2017; Ritchey et al., 2020; Rolfe et al., 2010). This success highlights the potential of automatic referral mechanisms to eliminate gender disparities in CR referral.

Despite equitable referral rates, males in our study were less likely to enroll in CR compared to females. This finding contrasts with existing research, which often reports lower enrollment rates among women, even when referral rates are comparable (Grace et al., 2016; Peters & Keeley, 2017; Ritchey et al., 2020; Rolfe et al., 2010). The lower enrollment rates among men may be partly explained by the higher prevalence of cardiovascular disease among males, as biological sex differences indicate men are more likely to experience heart disease compared to women (Government of Canada, 2018). This greater disease burden could lead to competing health priorities or the perception that CR is less important to pursue in the context of other medical needs. Additionally, societal or cultural norms that are specific to men in Northwest Ontario might deter them from enrolling in CR, such as the perception that CR is unnecessary or a reluctance to participate in structured health programs. While these explanations are speculative, they highlight the need for further research to explore and address the underlying factors contributing to sex- and gender-based disparities in CR enrollment in Northwest Ontario.

Conversely, women in our study were more likely to enroll in CR than men (OR = 2.06), despite the literature frequently identifying barriers such as caregiving responsibilities, transportation issues, or lack or perceived benefit (Rolfe et al., 2010; Samayoa et al., 2014). The automatic referral process implemented may have contributed to this increased enrollment by ensuring equitable access to CR. Samayoa et al. (2014) demonstrated that systematic referral strategies significantly enhanced CR enrollment rates among women, potentially addressing disparities in access. While our study did not specifically assess follow-up mechanisms, the observed higher enrollment rates among women suggest that the automatic referral process alone may play an important role in mitigating barriers to CR enrollment. This finding reflects an atypical pattern in Northwest Ontario, where women exhibited higher enrollment rates, contrary to the trends reported in the literature (Grace et al., 2016; Peters & Keeley, 2017; Ritchey et al., 2020; Rolfe et al., 2010). Future research should explore how such interventions specifically address gender-based obstacles and whether they can be optimized to improve enrollment rates among both men and women.

Logistic regression analysis revealed that having a partner significantly increased the likelihood of enrolling in CR, with partnered individuals being three times more likely to enroll compared to those without a partner. This finding aligns with existing research highlighting the importance of social support in health behaviors, including when enrolling in CR (Grace et al., 2008). Partners provide emotional encouragement, assist with transportation, and reinforce the perceived benefits of attending CR (Grace et al., 2008). Our results are also consistent with those of Fernandez and colleagues (2008), who reported that participants living with a partner were four times more likely to engage in CR following a percutaneous coronary intervention. Notably, while females were twice as likely to enroll in CR compared to males, the interaction between gender and partner status was not significant, suggesting that the positive impact of partner support on CR enrollment does not differ by gender. These findings emphasize the importance of partner support in promoting CR enrollment and highlight the need for future interventions to leverage social support systems to improve enrollment rates for all patients.

Drive time also emerged as an important barrier to CR enrollment. A study conducted in Southern Ontario found that patients with drive times exceeding 60 minutes were significantly less likely to enroll in CR (OR = 0.11; Brual et al., 2010). Our findings align with these results, as longer drives were associated with reduced enrollment, even with modest differences in travel times—patients who enrolled had an average drive time of 10.9 minutes compared to 12.3 minutes for those who did not enroll. While the average drive times in this study were relatively short compared to what might be expected in more remote or rural areas of Canada, the findings highlight the importance of proximity to CR programs even in urban or semi-urban settings. For individuals in more remote areas who face significantly longer travel times, the impact of distance is likely even greater. Expanding this work to include more rural and remote populations, such as those living in Northwest Ontario's satellite communities, could provide a more comprehensive understanding of how geographic barriers might affect CR enrollment. Strategies to improve access for these populations might include telehealth and home-based CR programs, as well as outreach initiatives such as partnerships with local healthcare providers in remote areas. These approaches could help reduce geographic barriers and ensure equitable access to CR for individuals in areas where travel times far exceed the averages observed in this study.

However, a limitation of our study is the focus on patients residing in Thunder Bay and nearby municipalities, excluding patients from more remote areas of Northwest Ontario. Due to varied constraints, we were unable to access patient records from satellite hospitals with affiliated CR programs. This may have led to an underestimation of the full impact of geographic barriers on CR enrollment, as patients from more isolated northern regions may experience greater geographical challenges in accessing CR (Brual et al., 2010). Future research should include data from these satellite programs to provide a more comprehensive understanding of how drive time impacts enrollment across Northwest Ontario. Implementing strategies like telehealth or home-based CR, a known effective means of delivering CR, could mitigate geographic barriers and improve access to CR in Northwest Ontario (Clark et al., 2015).

Apart from sex, partner status, and drive time that impacted CR enrollment, only a family history of cardiovascular disease was linked to a higher likelihood of completing CR. Other socioeconomic variables were not significantly associated with completion. This finding aligns with the literature, which suggests that the primary challenge in CR is often getting patients to enroll rather than complete the program once enrolled (Grace et al., 2012). For instance, Samayoa et al. (2014) found that the factors impacting CR enrollment were more varied and significant compared to those affecting completion, suggesting that the main challenge and disparities lie in getting patients to enroll. Once enrolled, fewer barriers seem to impact their ability to complete the program. Our study also observed fewer factors associated with completion than enrollment. Oosenbrug and colleagues (2016) suggest that once patients commit to the program, personal motivation or perceived risk becomes more influential in determining completion, while factors like support and accessibility might be more important for ensuring sustained participation.

5.2 Time to Rehospitalization

An important goal of completing CR is to reduce the risk of adverse outcomes, such as rehospitalization, which reflects improved cardiac health and reduced healthcare costs. In our analysis, patients who completed CR experienced a significantly longer time to rehospitalization compared to those who did not complete CR, with an average delay of 1.5 years. As such, completing CR was associated with a 31% lower risk of rehospitalization, demonstrating that completing CR can substantially delay cardiac-related rehospitalization (HR = 0.69, $p = 0.05$). This aligns with the well-documented protective effect of CR on cardiac-related rehospitalization reported in the literature (Alter et al., 2017; Anderson et al., 2016; Clark et al., 2005; Hambrecht et al., 2004; Heran et al., 2011; Jolliffe et al., 2001; Lawler et al., 2011; Martin et al., 2012; Milani et al., 1996; Milani & Lavie, 2007; Taylor et al., 2004).

However, after adjusting for relevant covariates in the multivariable Cox proportional hazards regression model, the protective effect of CR completion was attenuated and did not reach statistical significance (HR = 0.77, p = 0. 26). While the trend toward reduced rehospitalization remained, this may indicate that other factors, such as pre-existing conditions or previous cardiac interventions, may influence rehospitalization risk. For example, patients with previous coronary artery bypass grafting had a significantly higher risk of cardiac-related rehospitalization (HR = 1.90, $p < 0.01$), indicating that prior complex cardiac procedures may play a more prominent role in predicting rehospitalization than CR completion alone.

The lack of statistical significance in the adjusted model is more likely due to the limited sample size of patients who completed CR ($n = 96$), which reduced the statistical power needed to detect a meaningful difference in time to rehospitalization. Additionally, among those who did not complete CR, some may have attended a smaller number of exercise sessions, potentially diluting the strength of the association between CR completion and delayed rehospitalization. These limitations highlight the challenges of confidently detecting the effect of CR completion in smaller study populations, particularly when using multivariable Cox regression models that account for multiple covariates and require greater statistical power to isolate independent effects.

Comorbidities were also included in the multivariable Cox regression model to better understand their influence on the relationship between CR completion and time to rehospitalization. Adjusting for comorbidities likely attenuated the protective effect of CR completion, resulting in a loss of statistical significance ($HR = 0.77$, $p = 0.26$). While comorbidities were not directly associated with increased rehospitalization risk, they may indirectly affect CR outcomes by creating barriers to full participation. For example, patients with multiple or severe comorbidities may experience physical limitations, competing health priorities, or logistical challenges, which could diminish the effectiveness of CR in delaying rehospitalization (Brady et al., 2013). These findings emphasize the need to tailor CR programs to better support patients with complex comorbidities and enhance adherence.

Future research should aim to address these limitations by incorporating larger sample sizes and including patients from northern satellite programs. Such studies could investigate the independent and interactive effects of CR completion, including the number of sessions completed and geographical factors, on cardiac-related rehospitalization risk in Northwest Ontario. Additionally, targeted interventions to improve CR completion, particularly for high-risk patients with multiple comorbidities, could further enhance the long-term benefits of CR and reduce cardiac-related rehospitalization rates in this population.

5.3 Implications for Practice and Policy

Completing CR is well-established in the literature as an important intervention that significantly reduces morbidity and rehospitalization rates (Anderson et al., 2016; Hambrecht et al., 2004; Martin et al., 2012). Hambrecht and colleagues (2004) demonstrated that patients who completed CR experienced a 31% reduction in subsequent hospitalization within 12 months of program completion. Additionally, exercise-based CR programs offer substantial cost savings, with a 67.9% reduction in healthcare expenses, including rehospitalization and coronary reinterventions, compared to patients undergoing percutaneous coronary intervention alone. These findings align with our study's results, showing that CR completion may delay time to rehospitalization, reinforcing the importance of CR as an intervention.

However, as highlighted by Donio et al. (2019), cardiac-related rehospitalization rates remain higher in Northern Ontario compared to Southern Ontario, highlighting the need for region-specific interventions to ensure that eligible patients in this geographically isolated region can fully benefit from CR. The disparities in rehospitalization rates may be driven by the lack of access to early specialized care and diagnostic tests, making it essential to prioritize improving CR accessibility and effectiveness in Northwest Ontario.

Moreover, Martin et al. (2012) emphasized that greater session attendance, is strongly associated with improved outcomes. The more CR sessions patients attend, the better their health outcomes—an effect that has been consistently demonstrated across various studies (Alter et al., 2017, Hammill et al., 2010, Martin et al., 2012, 2013). This highlights the need for healthcare providers and policymakers to not only increase enrollment but also to ensure that patients complete the full CR program to maximize its benefits.

To improve CR enrollment and completion rates, especially in geographically isolated regions, policymakers should implement strategies that address barriers such as travel times and accessibility. Initiatives such as utilizing shorter programs (Farias-Godoy et al., 2018), incorporating telehealth and smartphone-based interventions (Varnfield et al., 2014), and expanding home-based CR options can mitigate geographic barriers and enhance CR utilization. By doing so, the overall effectiveness of CR programs can be significantly improved, leading to better health outcomes and reduced healthcare costs.

5.4 Strengths & Limitations

This study provides a comprehensive assessment of CR participation in a geographically distinct and isolated urban population in Northwest Ontario, focusing on factors that impact both enrollment and completion of CR. A significant strength of this research is its long follow-up period, which facilitated a thorough evaluation of important outcomes such as time to rehospitalization. Furthermore, the integration of data on factors such as drive times and partner status offers valuable insights that can help inform targeted interventions aimed at improving CR utilization and clinical outcomes in this population. For example, understanding that longer drives are associated with lower enrollment rates suggests that interventions such as telehealth, home-based CR programs, or satellite CR centers in underserved areas could mitigate geographic barriers. Similarly, the finding that having a partner significantly increases the likelihood of CR enrollment highlights the importance of leveraging social support systems. Targeted strategies could include family-centered CR education programs, caregiver involvement in CR sessions, or social support initiatives for patients without partners, such as peer support networks or group-based CR programs. These tailored approaches could help address specific barriers identified in this study, ultimately improving access to and participation in CR, particularly for individuals with who are geographically or socially isolated.

However, several limitations should be acknowledged. First, the study's reliance on secondary data sources meant that detailed individual-level socioeconomic status indicators, such as income or education, were not captured. The absence of such detailed socioeconomic data, which is recognized as an important determinant of CR completion (Castellanos et al., 2019; Shanmugasegaram et al., 2013), introduces potential for residual confounding. As a result, even after adjusting for other variables, unmeasured socioeconomic factors may still influence the findings.

The retrospective cohort design of this study, while valuable for examining long-term outcomes, presents certain limitations. Patients who died or were rehospitalized within one year of the index cardiac event were excluded based on eligibility criteria. This exclusion could introduce a form of survivorship bias, as the analysis focuses on patients who survived the early period following rehospitalization, potentially overestimating the protective effect of CR completion. Additionally, the number of CR exercise sessions in the non-exposed group was not accounted for, which could dilute the observed effects of CR. Furthermore, the timing of CR completion relative to rehospitalization was not explicitly assessed, raising the possibility of misclassification if some patients were rehospitalized before fully completing the program. These limitations highlight the need for careful consideration of study design and analytical approaches in future research to minimize bias and improve the robustness of findings.

In terms of generalizability, focusing on patients from a single regional health centre limits the external validity of the findings, particularly in comparison to larger urban centres with more resources. Although our results are consistent with previous research showing lower CR enrollment in populations facing geographic barriers (Brual et al., 2010), it is important to note that patients from more remote areas of Northwest Ontario were excluded. This exclusion may have led to an underestimation of the full extent of geographic barriers to CR access in this region.

Despite these limitations, this study makes a valuable contribution to the growing body of evidence on CR participation, particularly in a geographically isolated urban population. It highlights several challenges—such as geographic barriers, gender disparities in enrollment—but also identifies important opportunities for improving CR enrollment and completion rates. Expanding the use of telehealth and home-based CR programs could help address geographic barriers, while engaging partners to enhance social support may increase enrollment. Given the unique geographic and socioeconomic context of Northwest Ontario, interventions that target these region-specific factors are essential for increasing participation and improving patient outcomes.

Chapter 6: Conclusion

This study offers valuable insights into the factors affecting CR participation in a geographically isolated urban population in Northwest Ontario, emphasizing the important role of social support and geographical accessibility in CR enrollment. While the systematic referral processes at TBRHSC facilitated high referral rates, significant challenges in CR enrollment and completion persist, particularly for individuals without partner support or those residing farther from the CR program. The findings also highlight that completing CR can substantially delay time to rehospitalization, highlighting the importance of focused strategies to enhance CR engagement. To address these challenges, implementing targeted enrollment and adherence interventions, such as early follow-up clinics, personalized patient education, and systematic tracking of enrollment progress, could improve participation rates. Enhancing social support networks by involving family members or caregivers in CR programming and improving geographical accessibility through home-based CR options and telehealth services are additional strategies that could increase participation. These initiatives will be important for maximizing the benefits of CR and reducing the burden of cardiovascular disease in this unique and geographically diverse region.

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Appendix A

Table A1. The International Classification of Disease 10th Revision (ICD 10) for common cardiac conditions.

Cardiac condition	ICD-10 codes
Acute myocardial infarction	I21, I22
Unstable angina	I20
Coronary artery bypass graft with valve surgery	1IJ76 + 1HU, 1HV
Coronary artery bypass graft, isolated	1IJ76
Percutaneous coronary intervention	1IJ26, 1IJ50, 1IJ55, 1IJ57
Congestive heart failure	I50
Valve surgery	1HU, 1HV

Table A2. Summary of study variables, measurements, and coding used in the analyses.

Variables	Unit/value	Type	Source & derivation
Outcome variable			
Referral	Not referred (coded as 0) Referred (coded as 1)	Categorical, Binary	Obtained from the EMR; order history, physician notes
Enrollment	Not enrolled (coded as 0), Enrolled (coded as 1)	Categorical, Binary	Obtained from the EMR; scheduling application
Completion	Did not complete (coded as 0), Completed CR (coded as 1)	Categorical, Binary	Obtained from the EMR; scheduling application
Time to rehospitalization	days	Continuous	Obtained from the EMR; date of discharge from index admission to the date of cardiac-related readmission Cases excluded if readmission occurred within 180 days of the index admission
Continuous covariates			
Age	years	Continuous	Obtained from the EMR; index admission echocardiogram report or PCI summary report
Drive time	minutes	Continuous	Postal code obtained from EMR; drive time obtained from Google maps
Distance	kilometers	Continuous	Postal code obtained from EMR; drive distance obtained from Google maps
Categorical covariates			
Sex	Male (coded as 0) Female (coded as 1)	Categorical	Obtained from the EMR
Racialized & newcomer population	Lowest concentration (reference) Low concentration Moderate concentration High concentration	Categorical, Ordinal, 5 levels	Postal code obtained from EMR; postal code used to find neighbourhood in Google Maps, neighborhood quintile obtained from the Ontario Marginalization Index Interactive Map

	Highest concentration		
Material resources	Highest resources (reference) High resources Moderate resources Low resources Lowest resources	Categorical, Ordinal, 5 levels	Postal code obtained from EMR; postal code used to find neighbourhood in Google Maps, neighborhood quintile obtained from the Ontario Marginalization Index Interactive Map
Pre-existing individual comorbidities	Renal disease, heart failure, peripheral vascular disease, cerebrovascular disease, chronic obstructive pulmonary disease, malignancy, liver disease, previous myocardial infarction [coded as 0 for absent, coded as 1 for present]	Categorical	Obtained from the EMR; PCI summary report, physician notes, CR intake screening questionnaire, echocardiography report
Number of pre-existing CVD-related comorbidities	0-2 (coded as 0) 3 or more (coded as 1)	Categorical	Calculated from pre-existing individual comorbidities
Number of pre-existing non-CVD-related comorbidities	0-2 (coded as 0) 3 or more (coded as 1)	Categorical	Calculated from pre-existing individual comorbidities
Previous cardiac procedures	Previous PCI Previous CABG Previous valve repair/replacement Previous pacemaker [coded as 0 for absent, coded as 1 for present]	Categorical	Obtained from the EMR; PCI summary report, physician notes, CR intake screening questionnaire, echocardiography report
Most responsible diagnosis or cardiac procedure for referral to CR	NSTEMI (coded as 0; reference) STEMI (coded as 1) CHF (coded as 2)	Categorical, Nominal, 4 levels	Obtained from Health Records

	Angina (coded as 3)		
Rural residency	Urban (coded as 0; reference) Rural (coded as 1) Fly-in (coded as 2)	Categorical, Nominal, 3 levels	Postal code obtained from EMR; residency level obtained from Google maps; City of Thunder Bay boundary used to distinguish urban versus rural
Partner Status	No partner (coded as 0; reference) Partnered (coded as 1)	Categorical	Obtained from the EMR
Duke activity status index	Low (coded as 0; reference) Moderate (coded as 1) High (coded as 2)	Categorical, Ordinal, 3 levels	Obtained from the EMR; CR intake
Risk factors	Hypertension, hyperlipidemia, family History of CVD, current or former smoker, diabetes mellitus, BMI ≥ 30 [coded as 0 for absent, coded as 1 for present]	Categorical	Obtained from the EMR

Abbreviations: BMI, body mass index; CABG, coronary artery bypass grafting; CHF, congestive heart disease; CR, cardiac rehabilitation; CVD, cardiovascular disease; EMR, electronic medical record, NSTEMI, non-ST-elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-elevation myocardial infarction.

Appendix B

Table B1. Bivariate analysis of covariates thought to impact enrollment in CR with ORs (N = 416).

Variable	Total N	Enrolled N (%)	OR (95% CI)	p value
Predisposing factors				
Age of enrollees [n = 215], mean (SD)	416	65 (11)	0.98 (0.96-1.00)	0.02
Sex	416			
Male	283	139 (49.1%)	reference	
Female	133	76 (57.1%)	1.38 (0.91-2.09)	0.13
Racialized & newcomer populations[1]	412			0.78 (overall)
Lowest concentration	182	92 (50.5%)	reference	
Low concentration	167	91 (54.5%)	1.17 (0.77-1.78)	0.46
Moderate concentration	51	26 (51.0%)	1.02 (0.55-1.89)	0.96
High concentration	12	5 (41.7%)	0.70 (0.21-2.28)	0.55
Highest concentration	0	0	n/a	n/a
History before the index CVD event				
# of pre-existing CVD conditions	416			
0 – 2 conditions	281	167 (59.4%)	reference	
+ 3 conditions	135	48 (35.6%)	0.38 (0.25-0.58)	<0.01
# of pre-existing non-CVD conditions	416			
0 – 2 conditions	387	205 (53.0%)	reference	
+ 3 conditions	29	10 (34.5%)	0.47 (0.21-1.03)	0.06
Pre-existing conditions				
Renal disease	30	11 (36.7%)	0.52 (0.24-1.11)	0.09
On dialysis	4	0 (0.0%)	n/a	n/a
Congestive heart failure	33	12 (36.4%)	0.51 (0.24-1.06)	0.07
Peripheral vascular disease	33	14 (42.4%)	0.67 (0.33-1.37)	0.27
Aneurysm	11	3 (27.3%)	0.34 (0.09-1.31)	0.12
Endocarditis	2	1 (50.0%)	0.94 (0.06-15.0)	0.96
Valvular heart disease	66	24 (36.4%)	0.48 (0.28-0.82)	< 0.01
Cerebrovascular disease	41	15 (36.6%)	0.51 (0.26-0.98)	0.05
Pulmonary disease	54	23 (42.6%)	0.66 (0.37-1.17)	0.15
Liver disease	12	3 (25.0%)	0.30 (0.08-1.13)	0.08
Gastrointestinal disease	98	57 (58.2%)	1.41 (0.89-2.23)	0.14
Previous malignancy	56	29 (51.8%)	1.01 (0.57-1.77)	0.99
Previous myocardial disease	101	36 (35.6%)	0.42 (0.27-0.67)	< 0.01
Previous cardiac procedures				
Previous PCI	77	26 (33.8%)	0.41 (0.24-0.68)	< 0.01
Previous CABG	43	10 (23.3%)	0.25 (0.12-0.52)	< 0.01
Previous valve repair/replacement	3	2 (66.7%)	1.88 (0.17-20.87)	0.61
Previous pacemaker	6	2 (33.3%)	0.46 (0.08-2.55)	0.38
Enabling factors				

With partner (versus no partner)	416			
No	152	55 (36.2%)	reference	
Yes	264	160 (60.6%)	2.73 (1.80-4.14)	< 0.01
Material resources[1]	412			0.12 (overall)
Highest resources	70	44 (62.9%)	reference	
High resources	52	27 (51.9%)	0.64 (0.31-1.32)	0.23
Moderate resources	80	46 (57.5%)	0.80 (0.41-1.54)	0.50
Low resources	83	40 (48.2%)	0.55 (0.29-1.05)	0.07
Lowest resources	127	57 (44.9%)	0.48 (0.27-0.88)	0.02
Geographic				
Distance (km), mean (SD)	416			
Not enrolled (n = 201)		10.4 (13.3)		
Enrolled (n = 215)		8.9 (10.1)		
Distance (per kilometer increase)			0.99 (0.97-1.01)	0.20
Drive time (min), mean (SD)	416			
Not enrolled (n = 201)		12.3 (10.4)		
Enrolled (n = 215)		10.9 (6.4)		
Drive time (per minute increase)			0.98 (0.96-1.00)	0.10
Rural residency	69	33 (47.8)	0.83 (0.50-1.39)	0.48
Needs factors				
Most responsible diagnosis	416			0.08 (overall)
NSTEMI	215	100 (46.5%)	reference	
STEMI	128	77 (60.2%)	1.74 (1.11-2.71)	0.02
Congestive heart failure	8	3 (37.5%)	0.69 (0.16-2.96)	0.62
Angina	65	35 (53.8%)	1.34 (0.77-2.34)	0.30
Risk factors				
Hypertension	316	160 (50.6%)	0.84 (0.53-1.32)	0.45
Hyperlipidemia	233	121 (51.9%)	1.02 (0.70-1.51)	0.91
Family history of CVD	169	91 (53.8%)	1.16 (0.78-1.71)	0.47
Current or former smoker	230	117 (50.9%)	0.93 (0.63-1.37)	0.71
Diabetes mellitus	131	60 (45.8%)	0.71 (0.47-1.07)	0.10
BMI ≥ 30	146	81 (55.5%)	1.27 (0.84-1.90)	0.26

Notes
Abbreviations: CABG, coronary artery bypass grafting; CI, confidence interval; CR, cardiac rehabilitation; CVD, cardiovascular disease; NSTEMI, non-ST-elevation myocardial infarction; OR, odds ratio; PCI, percutaneous coronary intervention; STEMI, ST-elevation myocardial infarction.
Continuous variables: For age and drive time, the mean and SD are presented for the enrolled and not enrolled groups. The OR represents the change in odds of enrollment per unit increase in the variable.
Categorical variables: Total N represents the total number of patients with the characteristic. Enrolled N (%) is the number and percentage of patients with the characteristic who enrolled in CR. Reference categories are used for calculating ORs in the binary logistic regression. Overall p values are provided for variables with multiple categories, indicating the significance of the variable in the binary logistic regression model.
[1]The Ontario Marginalization Index censor's data with very small populations or where privacy could be compromised. As a result, some cases (n = 4) are censored to protect the confidentiality of cases in those areas.

Table B2. Bivariate analysis of covariates thought to be associated with completion of CR with ORs (N = 215).

Variables	Total N	Completed N (%)	OR (95% CI)	p value
Predisposing factors				
Age of completed [n = 90], mean (SD)	215	65 (12)	1.00 (0.98-1.03)	0.80
Sex	215			
Male	139	66 (47.5%)	reference	
Female	76	28 (36.8%)	0.65 (0.36-1.14)	0.13
Racialized & newcomer populations[1]	214			0.56 (overall)
Lowest concentration	92	36 (39.1%)	reference	
Low concentration	91	42 (46.2%)	1.33 (0.74-2.40)	0.34
Moderate concentration	26	11 (42.3%)	1.14 (0.47-2.76)	0.77
High concentration	5	1 (20.0%)	0.39 (0.04-3.62)	0.41
Highest concentration	0	0	n/a	n/a
History before the index CVD event				
# of pre-existing CVD conditions	215			
0 – 2 conditions	167	69 (41.3%)	reference	
+ 3 conditions	48	21 (43.8%)	1.11 (0.58-2.11)	0.76
# of pre-existing non-CVD conditions	215			
0 – 2 conditions	205	88 (42.9%)	reference	
+ 3 conditions	10	2 (41.9%)	0.33 (0.07-1.60)	0.17
Pre-existing conditions	215			
Renal disease	11	4 (36.4%)	0.78 (0.22-2.76)	0.71
On dialysis	0	0 (0.0%)	n/a	n/a
Congestive heart failure	12	2 (16.7%)	0.26 (0.06-1.22)	0.09
Peripheral vascular disease	14	7 (50.0%)	1.42 (0.48-4.21)	0.53
Aneurysm	3	1 (33.3%)	0.69 (0.06-7.74)	0.76
Endocarditis	1	1 (100.0%)	n/a	n/a
Valvular heart disease	24	10 (41.7%)	0.99 (0.42-2.34)	0.98
Cerebrovascular disease	15	6 (40.0%)	0.92 (0.32-2.69)	0.88
Pulmonary disease	23	5 (21.7%)	0.35 (0.13-0.98)	0.05
Liver disease	3	0 (0.0%)	n/a	n/a
Gastrointestinal disease	57	24 (42.1%)	1.01 (0.55-1.87)	0.97
Previous malignancy	29	14 (48.3%)	1.35 (0.62-2.96)	0.45
Previous myocardial disease	36	15 (41.7%)	0.99 (0.48-2.05)	0.98
Previous cardiac procedures				
Previous PCI	26	14 (53.8%)	1.74 (0.76-3.95)	0.19
Previous CABG	10	3 (30.0%)	0.58 (0.15-2.31)	0.44
Previous valve repair/replacement	2	0 (0.0%)	n/a	n/a
Previous pacemaker	2	2 (100.0%)	n/a	n/a
Enabling factors				
With partner	215			
No	55	22 (40.0%)	reference	
Yes	160	68 (42.5%)	1.12 (0.60-2.11)	0.72

Material resources[1]	214			0.13 (overall)
Highest resources	44	20 (45.5%)	reference	
High resources	27	16 (59.3%)	1.75 (0.66-4.60)	0.26
Moderate resources	46	20 (43.5%)	0.92 (0.40-2.12)	0.85
Low resources	40	17 (42.5%)	0.89 (0.37-2.10)	0.79
Lowest resources	57	17 (29.8%)	0.51 (0.22-1.16)	0.11
Geographic				
Drive distance (km), mean (SD)	215			
Did not complete (n = 125)		9.3 (11.2)		
Completed (n = 90)		8.3 (8.4)		
Drive distance (per kilometer increase)			0.99 (0.96-1.02)	0.47
Drive time (min), mean (SD)	215			
Did not complete (n = 125)		11.1 (6.4)		
Completed (n = 90)		10.6 (6.4)		
Drive time (per minute increase)			0.99 (0.95-1.03)	0.59
Rural residency	33	11 (33.3%)	0.65 (0.30-1.42)	0.28
Wait-time[2]	212			
≤ 90 days	147	64 (43.5%)	reference	
> 90 days	65	25 (38.5%)	0.81 (0.45-1.47)	0.49
Needs factors				
Most responsible diagnosis	215			0.47 (overall)
NSTEMI	100	37 (37.0%)	reference	
STEMI	77	34 (44.2%)	1.35 (0.74-2.47)	0.34
CHF	3	1 (33.3%)	0.85 (0.08-9.71)	0.90
Angina	35	18 (51.4%)	1.80 (0.83-3.92)	0.14
Duke activity status index[2]	203			0.01 (overall)
Low	56	15 (26.8%)	reference	
Moderate	118	59 (50.0%)	2.73 (1.37-5.47)	<0.01
High	29	11 (37.9%)	1.67 (0.64-4.34)	0.29
Risk factors	215			
Hypertension	160	67 (41.9%)	1.00 (0.54-1.87)	0.99
Hyperlipidemia	121	48 (39.7%)	0.81 (0.47-1.41)	0.46
Family history of CVD	91	46 (50.5%)	1.86 (1.07-3.23)	0.03
Current or former smoker	117	42 (35.9%)	0.58 (0.34-1.01)	0.05
Diabetes mellitus	60	21 (35.0%)	0.67 (0.36-1.25)	0.21
BMI ≥ 30	81	33 (40.7%)	0.93 (0.53-1.63)	0.80

Notes

Abbreviations: CABG, coronary artery bypass grafting; CI, confidence interval; CR, cardiac rehabilitation; CVD, cardiovascular disease; NSTEMI, non-ST-elevation myocardial infarction; OR, odds ratio; PCI, percutaneous coronary intervention; STEMI, ST-elevation myocardial infarction.

Continuous variables: For age and drive time, the mean and SD are presented for the did not complete and completed groups. The OR represents the change in odds of completion per unit increase in the variable.

Categorical variables: Total N represents the total number of patients with the characteristic. Completed N (%) is the number and percentage of patients with the characteristic who completed CR. Reference categories are used for

calculating ORs in the binary logistic regression. Overall p values are provided for variables with multiple categories, indicating the significance of the variable in the binary logistic regression model.
[1]The Ontario Marginalization Index censor's data with very small populations or where privacy could be compromised. As a result, some cases (n = 4) are censored to protect the confidentiality of cases in those areas.
[2]Reduce sample size due to data entry errors or omissions.

Table B3. Bivariate analysis of time to rehospitalization: HRs and 95% CI for covariates comparing hospitalized and non-hospitalized patients following CR (N = 391).

Variables	Total N	Hospitalized N (%)	HR (95% CI)	p value
Completed CR	391	166 (42.5%)	0.69 (0.47-1.00)	0.05
Predisposing factors				
Age (years) of hospitalized [n=166], mean (SD)	391	68 (12)	1.01 (0.99-1.02)	0.34
Sex				
Male	278	114 (41.0%)	reference	
Female	113	52 (46.0%)	0.90 (0.64-1.25)	0.52
Racialized & newcomer populations[1]	388			0.82 (overall)
Lowest concentration	171	70 (40.9%)	reference	
Low concentration	156	68 (43.6%)	1.13 (0.80-1.58)	0.49
Moderate concentration	50	21 (42.0%)	1.11 (0.68-1.82)	0.68
High concentration	11	6 (54.5%)	1.40 (0.60-3.23)	0.44
Highest concentration	0	0	n/a	n/a
History before the index CVD event				
# of pre-existing CVD conditions				0.07 (overall)
0 – 2 conditions	268	92 (34.3%)	reference	
+ 3 conditions	123	74 (60.2%)	1.33 (0.98-1.81)	0.07
# of pre-existing non-CVD conditions				0.11 (overall)
0 – 2 conditions	361	150 (41.6%)	reference	
+ 3 conditions	30	16 (53.3%)	1.52 (0.90-2.55)	0.12
Pre-existing conditions				
Renal disease	31	17 (54.8%)	1.44 (0.87-2.39)	0.15
On dialysis	5	2 (40.0%)	2.39 (0.59-9.71)	0.23
Congestive heart failure	29	21 (72.4%)	1.22 (0.77-1.92)	0.41
Peripheral vascular disease	30	19 (63.3%)	1.36 (0.84-2.21)	0.21
Aneurysm	13	9 (69.2%)	1.63 (0.83-3.21)	0.16
Endocarditis	2	2 (100.0%)	4.47 (1.09-18.34)	0.04
Valvular heart disease	63	37 (58.7%)	1.20 (0.83-1.73)	0.33
Cerebrovascular disease	35	19 (54.3%)	1.42 (0.88-2.30)	0.15
Pulmonary disease	49	28 (57.1%)	1.16 (0.77-1.74)	0.48
Liver disease	9	5 (55.6%)	0.90 (0.37-2.21)	0.82
Gastrointestinal disease	87	38 (43.7%)	1.29 (0.90-1.87)	0.17
Previous malignancy	53	25 (47.2%)	1.25 (0.81-1.91)	0.31
Previous myocardial disease	99	61 (61.6%)	1.22 (0.89-1.67)	0.22
Previous cardiac procedures				
Previous PCI	74	44 (59.5%)	1.35 (0.95-1.91)	0.10
Previous CABG	42	31 (73.8%)	1.88 (1.26-2.78)	<0.01

Previous valve repair/replacement	5	3 (60.0%)	0.56 (0.18-1.79)	0.33
Previous pacemaker	7	4 (57.1%)	2.67 (0.98-7.29)	0.06
Enabling factors				
With partner (versus no partner)	252	103 (40.9%)	0.85 (0.61-1.17)	0.31
Material resources[1]	388			0.69 (overall)
Highest resources	68	28 (41.2%)	reference	
High resources	54	20 (37.0%)	1.28 (0.71-2.31)	0.41
Moderate resources	69	27 (39.1%)	1.15 (0.67-1.98)	0.61
Low resources	80	37 (46.3%)	1.44 (0.87-2.39)	0.16
Lowest resources	117	53 (45.3%)	1.29 (0.81-2.08)	0.29
Geographic				
Distance (km), mean (SD)	391			
Not hospitalized (n = 225)		10 (13)		
Hospitalized (n = 166)		8 (9)		
Distance travelled (per km away)			0.99 (0.98-1.01)	0.27
Drive time (min), mean (SD)	391			
Not hospitalized (n = 225)		12 (10)		
Hospitalized (n = 166)		11 (7)		
Drive time (per minute increase)			0.99 (0.97-1.01)	0.26
Rural residency	63	22 (34.9%)	0.65 (0.40-1.03)	0.07
Needs factors				
Most responsible diagnosis				0.52 (overall)
NSTEMI	202	84 (41.6%)	reference	
STEMI	117	42 (35.9%)	0.77 (0.53-1.12)	0.18
CHF	8	5 (62.5%)	1.24 (0.50-3.08)	0.64
Angina	64	35 (54.7%)	0.92 (0.62-1.37)	0.67
Risk factors				
Hypertension	294	137 (46.6%)	0.91 (0.61-1.36)	0.65
Hyperlipidemia	215	100 (46.5%)	0.79 (0.57-1.09)	0.14
Family history of CVD	159	70 (44.0%)	1.32 (0.97-1.80)	0.08
Current or former smoker	212	85 (40.1%)	1.16 (0.85-1.59)	0.34
Diabetes mellitus	121	67 (55.4%)	1.23 (0.90-1.68)	0.20
BMI ≥ 30	135	60 (44.4%)	0.80 (0.58-1.10)	0.17

Notes

Abbreviations: CABG, coronary artery bypass grafting; CI, confidence interval; CR, cardiac rehabilitation; CVD, cardiovascular disease; HR, hazard ratio; NSTEMI, non-ST-elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-elevation myocardial infarction.

Continuous variables: For age and drive time, the mean and SD are presented for those patients hospitalized and not hospitalized groups. The HR represents the change in odds of being hospitalized per unit increase in the variable.

Categorical variables: Total N represents the total number of patients with the characteristic. Hospitalized N (%) is the number and percentage of patients with the characteristic who where hospitalized. Reference categories are used

for calculating HRs in the survival analysis. Overall p values are provided for variables with multiple categories, indicating the significance of the variable in the survival analysis.
[1]The Ontario Marginalization Index censor's data with very small populations or where privacy could be compromised. As a result, some cases (n = 3) are censored to protect the confidentiality of cases in those areas.