8-16-2019

# A Comparison of Cardiac Rehabilitation Services and Outcomes in the Great Lakes Central Region (Southwestern Ontario and Southeastern Michigan)

Cayla Wood
*University of Windsor*

# A Comparison of Cardiac Rehabilitation Services and Outcomes in the Great Lakes Central Region (Southwestern Ontario and Southeastern Michigan)

By
Cayla Wood

A Thesis
Submitted to the Faculty of Graduate Studies
through the Department of Kinesiology
in Partial Fulfillment of the Requirements for
the Degree of Master of Human Kinetics at the
University of Windsor

Windsor, Ontario, Canada

**A Comparison of Cardiac Rehabilitation Services and Outcomes in the Great Lakes Central Region (Southwestern Ontario and Southeastern Michigan)**

by

Cayla Wood

APPROVED BY:

_____

S. Fox
Faculty of Nursing

_____

K. Milne
Department of Kinesiology

_____

C. McGowan, Advisor
Department of Kinesiology

August 16th, 2019

## Declaration of Originality

I hereby certify that I am the sole author of this thesis and that no part of this thesis has been published or submitted for publication.

I certify that, to the best of my knowledge, my thesis does not infringe upon anyone's copyright nor violate any proprietary rights and that any ideas, techniques, quotations, or any other material from the work of other people included in my thesis, published or otherwise, are fully acknowledged in accordance with the standard referencing practices. Furthermore, to the extent that I have included copyrighted material that surpasses the bounds of fair dealing within the meaning of the Canada Copyright Act, I certify that I have obtained a written permission from the copyright owner(s) to include such material(s) in my thesis and have included copies of such copyright clearances to my appendix.

I declare that this is a true copy of my thesis, including any final revisions, as approved by my thesis committee and the Graduate Studies office, and that this thesis has not been submitted for a higher degree to any other University or Institution.

## Abstract

Cardiac rehabilitation (CR) is a secondary prevention program known to improve clinical outcomes and health-related quality of life in individuals with cardiovascular disease, yet participation and completion rates are suboptimal. Additionally, a CR model or models that is/are most efficient for all cohorts of participants has yet to be established. The purpose of this study was to compare models of care from four geographically close CR sites that span an international border through examination of program characteristics and database variables. Participants were also characterized and examined for potential predictors of program completion at one site. The most impactful findings were: 1) sites may want to consider collecting a standardized data battery during programming and implementing participation incentives to enhance program completion; 2) the collection of point/date of referral, travel distance, and availability of exercise equipment at home and gym membership, may want to be considered by all sites; and 3) increasing age and higher education were associated with program completion. This research will provide a foundation for comparisons of the "granular" program and participant details across sites to maximize participant and program success. As such, the expertise from all sites can be leveraged to lead discussions that strategize next steps in developing an ideal CR model or models that not only provide participant benefit, but also cost-efficient programming solutions.

**Acknowledgements**

I dedicate this thesis to all of the passionate individuals that have helped me throughout my journey. Firstly, this thesis would not have been possible without the constant support and guidance from my advisor *Dr. Cheri McGowan*. Thank you for your dedication to my success, the countless opportunities you have provided me with, and your sharing of expertise.

Thank you to my committee members for your constant support and accommodation. Thank you *Dr. Kevin Milne* for your guidance and making me think critically. Thank you *Dr. Susan Fox* for sharing your knowledge and unique perspective.

To the investigators and experts from all sites involved, your constant guidance was imperative to the success of this thesis and it was a privilege to work with you.

To my friends, especially my lab mates, thank you for your motivation and support throughout this process. Everything seems more attainable when you have a team to support you.

To a specific loved one, thank you for being by my side through the entirety of this process. Your confidence in my abilities is greatly supportive, as is your constant positivity, patience, and faith. Thank you.

Finally, to my parents, you exemplify the definition of endless love and support. I appreciate your encouragement now and always. Thank you for always believing in me and teaching me to have faith in all situations.

## Table of Contents

## List of Tables

## List of Figures

## List of Appendices

## Abbreviations

| | |
|---|---|
| **AACVPR** | American Association of Cardiovascular and Pulmonary Rehabilitation |
| **ACC** | American College of Cardiology |
| **ACS** | Acute Coronary Syndrome |
| **AHA** | American Heart Association |
| **CABG** | Coronary Artery Bypass Grafting |
| **CACPR** | Canadian Association of Cardiovascular Prevention and Rehabilitation |
| **CAD** | Coronary Artery Disease |
| **CCN** | Cardiac Care Network |
| **CCRR** | Canadian Cardiac Rehab Registry |
| **CCS** | Canadian Cardiovascular Society |
| **COPD** | Chronic Obstructive Pulmonary Disease |
| **CR** | Cardiac Rehabilitation |
| **CRP** | Cardiac Rehabilitation Program |
| **CVD** | Cardiovascular Disease |
| **ECG** | Electrocardiogram |
| **HFmrEF** | Heart Failure with a Mid-range Ejection Fraction |
| **HFpEF** | Heart Failure with a Preserved Ejection Fraction |
| **HFrEF** | Heart Failure with a Reduced Ejection Fraction |
| **HRmax** | Heart Rate Max |
| **HRQoL** | Health-Related Quality of Life |
| **LDL** | Low-Density Lipoproteins |
| **MI** | Myocardial Infarction |
| **NO** | Nitric Oxide |
| **NSTEMI** | Non-ST-Segment Elevation Myocardial Infarction |
| **PCI** | Percutaneous Coronary Intervention |
| **RM** | Repetition Maximum |
| **ROS** | Reactive Oxygenated Species |
| **RPE** | Rating of Perceived Exertion |
| **SMC** | Smooth Muscle Cell |
| **STEMI** | ST-Segment Elevation Myocardial Infarction |
| **$VO_2$** | Volume of Oxygen; Oxygen Consumption |

# Chapter 1: Literature Review

## 1.1 Cardiovascular Disease

Cardiovascular disease (CVD) is currently the leading cause of death worldwide, taking 17.9 million lives in 2016 alone.[1] CVD encompasses a group of disorders that affect both the heart and blood vessels of the heart, brain, and limbs.[1] The majority of CVD-related mortality, however, because of coronary artery disease (CAD), which is a worldwide epidemic accounting for over nine million deaths in 2016.[2]

CAD occurs when blood vessels that lead to the heart are diseased, and it may also be referred to as: coronary heart disease, ischaemic heart disease, atherosclerotic heart disease, or simply atherosclerosis.[1,2] The pathological process of CAD is atherosclerosis, which is the formation of fatty deposits or plaque in the blood vessels that then limits blood flow and causes blood clots.[3]

Within Canada, the total cost of CVDs in 2005 was approximately $20.9 billion and is predicted to rise to $28.3 billion by 2020.[4] CAD remains a major cause of death in Canada, falling second only to cancer, where approximately 1 in 12 (2.4 million) Canadians equal to or over the age of 20 years lived with CAD in 2012-2013.[5] In the province of Ontario, statistics do not specifically address the prevalence of CAD, but more than 24,000 Ontarians died in 2012 from CVD.[6]

Across a national border to the United States, CVD remains the leading cause of death and it is estimated by 2035 that 45.1% of the adult population (>130 million people) will be diagnosed with CVD, resulting in an annual $1.1 trillion total cost for CVD.[7] CAD currently accounts for 43.8% of the lives lost to CVD in the

United States and heart disease, which includes CAD is ranked as the predominant cause of death in many states, including Michigan.[7,8]

### 1.1.1 The Pathogenesis of Coronary Artery Disease

The pathological process of CAD, involves atherosclerosis in the coronary arteries, leading to a myriad of serious, potentially fatal, consequences. Atherosclerosis affects the layers of the arteries by way of endothelium dysfunction, the invasion of lipids, pro-inflammatory responses, and the multiplication/movement of vascular cells.[9] To understand the pathological process of atherosclerosis, it is essential to comprehend the structure of a human artery.

The arteries in the human body are composed of three layers: the tunica intima (the inner most layer also known as the endothelium, which houses the endothelial cells), the tunica media (the middle layer), and the adventitia (representing the outermost layer).[3]

In the absence of atherosclerosis and during vascular homeostasis, endothelial cells interact with the passing blood and keep it in a liquid state.[3] A normal functioning endothelium controls blood clot formation and breakdown by releasing plasminogen activators and other antithrombotic agents.[3] Further, during vascular homeostasis vasodilators (e.g., nitric oxide [NO]) and vasoconstrictors are released by the endothelium to maintain equilibrium of the vascular tone.[10] Vasodilators cause the blood vessels to widen, whereas vasoconstrictors cause the blood vessels to narrow.[10,11] Thus, during homeostasis a healthy vascular tone and diameter is maintained.[10,11] NO is essential to vascular homeostasis and its

biosynthesis can become impaired with oxidative stress (i.e., the production of pro-atherogenic reactive oxygenated species [ROS]).[9] The cells responsible for the maintenance of vascular tone by relaxing and contracting in response to NO are smooth muscle cells (SMCs), primarily found within the layer of the artery surrounding the endothelium, the tunica media.[3] However, throughout the atherogenic process, the migration and multiplication of SMCs into the endothelium supports the formation of atherosclerotic plaque through a series of steps.[3]

The pathogenesis of atherosclerosis, and the eventual formation of atherosclerotic plaque, begins when dysfunction or injury occurs to the endothelium from the presence of one or more risk factors.[3,12] The most common site of injury involves sections of the arteries that are exposed to augmented shear stress and disturbed blood flow, such as curvatures and branch points.[13] The immune system responds to these injuries, classifying atherosclerosis as an inflammatory disease.[14] In more detail, pro-inflammatory signaling proteins (i.e., cytokines) are released after the initiation of an injury to the endothelium and increase its permeability.[15] This allows for the movement of lipoprotein particles (i.e., particles that carry cholesterol in the blood), particularly low-density lipoproteins (LDL), into the sub-endothelium space (Figure 1, #1).[3,12,16,17] LDL undergoes oxidation once in the sub-endothelium space and the oxidized LDL along with other sources of oxidative stress (i.e., the risk factors discussed in the subsequent section) further increase the concentration of cytokines (Figure 1, #2).[3]

Moreover, cytokines promote the expression of adhesion molecules on the endothelium as a response to the endothelium injury.[15,16] This pro-inflammatory response attracts immune cells such as monocytes, encouraging the binding of the immune cells to the expressed adhesion molecules and then the movement of the immune cells into the sub-endothelium space (Figure 1, #3).[3,15,16]

Once in the sub-endothelium space, the monocytes are converted to macrophages, which have scavenger receptors to attach to the oxidized LDL, and then the macrophages ingest the oxidized LDL (Figure 1, #4).[3,16] After the macrophages consume the oxidized LDL, the macrophages become foam cells, which further enhance the pro-inflammatory response by releasing more cytokines (Figure 1, #5).[3,16] Foam cells continue to manifest and multiply within the sub-endothelium space and form the lipid-rich core of atherosclerotic lesions, commonly referred to as “plaque”.[3,16]

The lipid-rich core of the plaque becomes surrounded by a fibrous capsule or cap.[3,16] This fibrous structure begins its formation with the movement of SMCs from the tunica media into the sub-endothelium space, where SMC proliferation is continued (Figure 1, #6).[3,16] The SMCs uptake oxidized LDL and release extracellular matrix molecules that eventually create the fibrous cap that surrounds the lipid-rich core of the plaque (Figure 1, #7).[3,16] This fibrofatty lesion continues to become more fibrous, which may occur with endothelial cell and SMC death (Figure 1, #8).[3] Eventually, calcification can occur as well.[3]

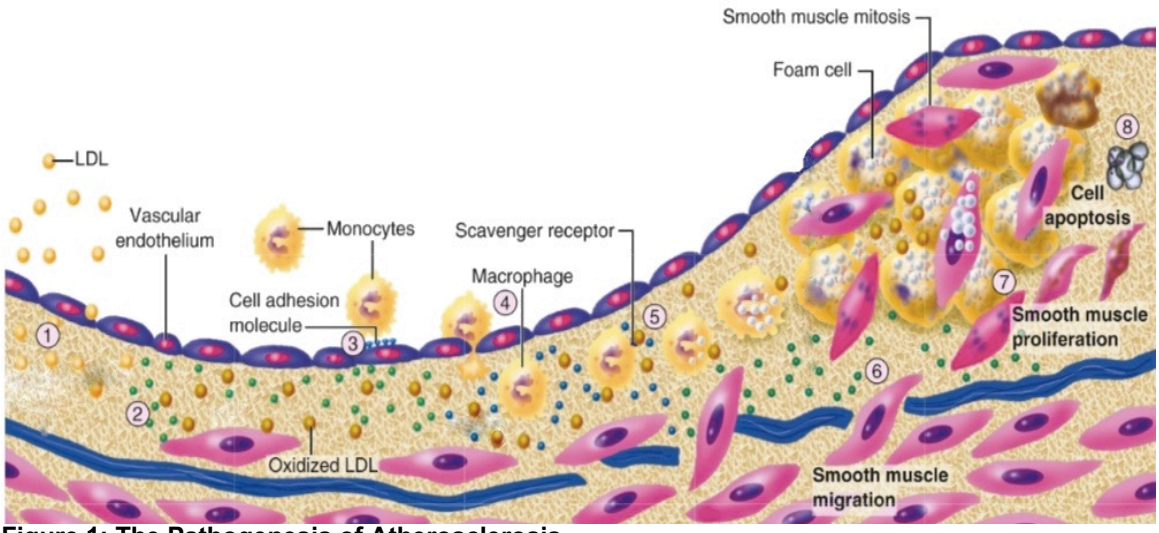


**Figure 1: The Pathogenesis of Atherosclerosis**
The green and blue spheres represent cytokines. Modified from Zipes and colleagues.[3]

As evident by the pathogenic process described above, atherosclerosis is progressive, with clinical symptoms appearing years after its onset when plaque formation in the arteries is substantial enough to reduce blood flow.[3] Initially, the artery can compensate for the presence of plaque by remodeling the innermost layer of the endothelium.[18] The two forms of remodeling are negative remodeling, described by a decrease in the diameter of the artery, and positive remodeling, which expands the diameter of the artery.[18] Negative remodeling is associated with stable plaque, whereas unstable plaque is prominent with positive remodeling.[18] However, the diameter expansion with positive remodeling is eventually inefficient in preventing blood flow impairments and the unstable plaque associated with positive remodeling can produce a thrombus due to complications such as the plaque fissuring, rupturing or eroding.[3,19] These disturbances to the plaque and the ensuing thrombus formation may result in a myocardial infarction (MI).[3]

### 1.1.2 Risk Factors

Modifiable risk factors for CVD, such as physical inactivity and poor diet have contributed to the increasing prevalence of atherosclerosis.[3] Fortunately, lifestyle interventions (e.g., increasing physical activity) when paired with cessation of smoking, can reduce the chance of experiencing a secondary vascular event by approximately 75%.[1]

The modifiable risk factors for CVD that are influenced by lifestyle interventions include hypertension (high blood pressure), hyperlipidemia (high blood cholesterol), diabetes, poor diet, obesity, the use of tobacco, psychological factors (depression, anxiety, and stress), social factors, and physical inactivity.[1,17,20,21] Unfortunately, some risk factors for CVD are non-modifiable, including sex, increasing age, ethnicity, and genetics/family history.[21,22]

### 1.1.3 Modifiable Risk Factors

The leading modifiable risk factor for CVD is hypertension with 24.1% of men and 20.1% of women over the age of 18 years diagnosed globally in 2015.[1] CAD is a CVD, where the increased pressure on the blood vessels that coincides with hypertension injures the endothelium and thus makes it more susceptible to the pathogenesis of atherosclerosis.[23] Injury to the endothelium also occurs from the activation of many cellular signaling pathways that correspond with the pathogenesis of hypertension, leading to the production of ROS and therefore oxidative stress, which stimulates the inflammatory response associated with atherosclerosis.[23] Additionally, the bioavailability of NO is reduced from the hypertension-produced ROS (e.g., superoxide anions), and vascular tone is

impaired.[9,23] However, hypertension and its impact on CAD can be minimized with various lifestyle interventions such as dietary changes (e.g., adherence to the Dietary Approaches to Stop Hypertension or the Mediterranean diet, reduced alcohol consumption, reduced sodium intake), body weight management, smoking cessation, stress management, and increased physical activity.[24,25]

Undoubtedly, the pathogenesis of atherosclerosis occurs in the presence of elevated blood cholesterol levels, thus the modifiable CVD risk factor of hyperlipidemia, particularly elevated LDL, is imperative to the development of CAD.[3,26] LDL is present for the entire process of plaque development; from sub-endothelium invasion to the formation of the lipid-rich core of the plaque.[3,16] Pharmacotherapy (e.g., statins) is commonly recommended in guidelines for controlling blood cholesterol levels, but smoking cessation, increased physical activity, body weight management, and a healthy diet provide favorable blood cholesterol changes as well.[27–29]

Diabetes is also a modifiable risk factor for CVD, but the pathophysiology between diabetes and atherosclerosis warrants further investigation.[9,30] However, it is understood that hyperglycemia is correlated with oxidative stress (i.e., ROS) leading to endothelium dysfunction.[9,30] It is known that oxidative stress and the affiliated ROS increase the appearance of cytokines and begin the cascade of events that leads to the formation of atherosclerotic plaque.[3] The detriments of diabetes can be mitigated with nutritional therapy (e.g., implementing a healthy

diet while monitoring the intake of carbohydrates), body weight management, smoking cessation, physical activity, and psychosocial management.[31]

A poor diet is a modifiable CVD risk factor that can significantly impact the development of atherosclerosis. More specifically, to control the pathogenesis of atherosclerosis by lowering blood cholesterol levels (e.g., LDL levels) a limited dietary consumption of trans fats, saturated fats, and cholesterol is endorsed.[27,28] It is also suggested that individuals adopt a Mediterranean or similar diet to reduce the risk of CVD and related events.[27,28] The Mediterranean diet incorporates whole grains, legumes, fresh vegetables, fruits, nuts, seeds, extra-virgin olive oil, moderate quantities of fish, low amounts of dairy products, and very low amounts of red meat, thus a diet opposite to this would be considered unfavourable or a poor diet for the prevention of CAD.[32] Preliminary research demonstrates that adherence to the Mediterranean diet lowers blood cholesterol levels (i.e., LDL), decreases oxidative stress while supplying antioxidants, decreases inflammation, and increases immune function, all representing protective mechanisms against the development and progression of atherosclerosis.[32]

Another modifiable risk factor for CVD is obesity. Obesity is accompanied by an unfavourable amount of adipose tissue, which is recognized as an endocrine organ that plays a role in the regulation of the endothelium.[33] In detail, a high amount of adipose tissue contributes to the inflammatory response with the release of pro-inflammatory factors (e.g., cytokines) and the invasion of macrophages, which both stimulate the pathogenesis of atherosclerosis.[33,34] Additionally, pro-and anti-inflammatory adipocytokines are not produced in balance by adipose tissue

and can lead to endothelium dysfunction and vascular remodeling.[33] Overall, adipose tissue stimulates an inflammatory response that contributes to the process of atherosclerosis.[34] Fortunately, obesity can be modified, alleviating the effects on atherosclerosis, with a healthy weight loss program that incorporates a reduced caloric intake and healthy diet (e.g., the Mediterranean diet).[35] Increased physical activity is also paramount, and other lifestyle interventions (e.g., education, goal-setting, psychological counselling) delivered by a multidisciplinary team that encourage both diet and physical activity changes.[35]

Tobacco use (i.e., cigarette smoking) is a modifiable CVD risk factor that contributes to atherosclerosis during the full duration of its pathogenesis, starting with injury to the endothelium from the oxidative stress (i.e., the presence of ROS) caused by cigarette smoke.[36] The ROS from the presence of cigarette smoke also cause the oxidation of LDL, and it has been established that cigarette smoking increases the concentration of LDL in the blood.[36,37] Overall, the release of inflammatory cytokines is amplified with cigarette smoking promoting the recruitment of immune cells (e.g., monocytes), and adhesion molecule expression is intensified, which together allows monocytes to bind and move into the sub-endothelium space, eventually creating foam cells.[3,9,15,16,36] Reduced NO formation is also associated with cigarette smoking, and thus vasodilation is impaired and therefore overall vascular homeostasis.[9,36] However, with smoking cessation endothelium dysfunction can be reversed and endothelium function restored, as seen by the improvement in the vasodilation capabilities of the arteries within only one-year post-cigarette smoking.[36,38] There is a universal consensus in smoking

cessation (i.e., tobacco cessation) guidelines that individuals should be provided guidance on how to quit smoking and support through behavioural and pharmacological treatment.[39]

Furthermore, psychological factors such as depression, anxiety, and stress, and various social factors (e.g., social isolation or absence of social support and integration) are classified as modifiable risk factors for CVD.[40,41] Research examining psychological concerns and CVD is still preliminary with the majority of studies focusing on depression, suggesting that the presence of depression increases the inflammatory response.[40,42] Similar to depression, anxiety and stress are also proposed to increase the inflammatory response.[40,42] A prevalence of social factors such as social isolation has also been shown to increase levels of inflammation, whereas social support and integration decrease levels of inflammation.[43,44] Since atherosclerosis is an inflammatory disease, the activation of the inflammatory response by various psychological and social factors only propagate the entire process of plaque formation.[14] Suggestions to modify psychological factors and social factors include increased social support, with concomitant education on how to manage these factors and establish self-help strategies.[17] Individual or group counselling is beneficial as well to discuss how to implement lifestyle interventions to manage stress, and improve diet, tobacco use, and physical activity habits, as psychological factors are interrelated with these previously mentioned modifiable CVD risk factors.[17,40] Moreover, referral to a mental health specialist may be beneficial for further treatment (e.g., psychotherapy) or pharmacotherapy when required.[17]

Lastly, the modifiable CVD risk factor of physical inactivity contributes to the prevalence and severity of many other modifiable CVD risk factors (as mentioned previously) and to the development of atherosclerosis.[45] In regard to the pathogenesis of atherosclerosis, the lack of shear stress associated with physical inactivity leads to endothelium dysfunction commencing the atherosclerosis process.[3,45] Moreover, physical inactivity also results in unfavourable levels of cholesterol in the blood with increased LDL levels contributing to the development of plaque.[3,17,45] Fortunately, the consequences of physical inactivity can be combatted by simply increasing physical activity levels.[45] Shear stress in the vasculature is increased during bouts of physical activity, stretching the artery walls, which promotes the health of endothelial cells.[45] Additionally, chronic physical activity positively alters blood lipid levels (e.g., a reduction in LDL levels).[45] Chronic physical activity also increases the availability of NO, which promotes vascular homeostasis as an essential vasodilator.[9,46] Additionally, a decrease in oxidative stress is associated with physical activity by reducing the prevalence of ROS, even in individuals with CVD, thus diminishing the pro-inflammatory response by mitigating the release of cytokines and consequently the exposure of adhesion molecules.[46,47] Evidently, physical activity can prevent the occurrence and progression of atherosclerosis and positivity impact the effect of other modifiable CVD risk factors as well.

### 1.1.4 Non-modifiable Risk Factors

As mentioned, not all risk factors for CVD are modifiable. For instance, sex is one such non-modifiable CVD risk factor.[21,22] Both within Canada and the United

States, CAD is more prevalent in men and appears 10 years earlier than it does in women.[5,7] However, as age increases, the difference in prevalence of CAD between the sexes narrows, perhaps due to women losing the protective effect of estrogen after menopause.[5] Estrogen is thought to protect women by lowering LDL levels and SMC multiplication and movement, while promoting vasodilation and beneficial endothelial cell multiplication and movement.[48]

Likewise, age is a non-modifiable CVD risk factor.[21,22] The natural process of aging is associated with stiffening of the arteries and endothelium dysfunction.[49] As blood vessels age, production of NO is reduced and movement of SMCs into the sub-endothelium space is common.[49] Therefore, when an individual's age increases the individual becomes more susceptible to CVD, however by altering the formerly mentioned modifiable risk factors the influence of aging can be minimized.[50]

Within Canada and the United States, there exists discrepancies in the prevalence of CVD risk factors across different ethnicities.[51] This emphasizes the significance of ethnicity as a non-modifiable CVD risk factor.[21,22] For example, hypertension is more common in Blacks compared to Whites, and diabetes is more common in Hispanics compared to Whites.[51] Diabetes is also more common in Indigenous peoples compared to Whites, as is abdominal obesity and smoking.[51] Compared to Whites, differences have been observed between Arab, Chinese and Filipino individuals, but the research is limited (compared to that conducted with Blacks, Hispanics, and Indigenous peoples) to propose a definite difference.[51]

Overall, the occurrence of risk factors for CVD events varies amongst ethnicities, however the reasoning for this requires future investigation.[51]

Family history increases both the risk and severity of CAD and therefore the chance of experiencing an MI.[52,53] A study by Pandey and colleagues[54] defined premature family history as the occurrence of an MI (e.g., fatal or non-fatal) or a clinical intervention (e.g., percutaneous coronary intervention [PCI], and/or coronary artery bypass grafting [CABG]) before 55 years of age in first-degree relatives who are men, and before 65 years of age in first-degree relatives who are women. This multi-ethnic study concluded that the incidence and progression of CAD is correlated with family history, especially if parents and siblings both have premature CAD.[54]

### 1.1.5 Health Complications Associated with Coronary Artery Disease

Many health complications can emerge with CAD and the associated presence of atherosclerosis. When a thrombus impedes blood flow in a coronary artery, inadequate amounts of oxygen are delivered to the cardiomyocytes – the subsequent impairment of blood flow of which is termed myocardial ischemia.[3] In many but not all individuals, a temporary symptom of myocardial ischemia is angina pectoris, which is pain or discomfort in the chest and adjacent areas (e.g., neck, jaw, arms and the abdomen).[3] However, the exact location, severity, and duration of angina pectoris can vary drastically between individuals, particularly in women.[3,55,56] Typical or stable angina pectoris is usually stimulated by over exertion and is relieved quickly by rest and short-acting nitroglycerin.[3] Dissimilarly, unstable angina pectoris is more severe and unpredictable, occurring at rest or

while sleeping, and relief from rest and nitroglycerin is delayed.[3] In approximately one third of individuals treated for ischemia, no symptoms are present, and this is known as silent (asymptomatic) ischemia and therefore lacks warning signs of the condition.[3]

Furthermore, when a thrombus impedes the blood flow in a coronary artery and myocardial ischemia is not reversed or blood flow restored, an MI can develop and if long or severe enough, can cause cardiomyocyte death.[3,57] The most recent universal definition of MI incorporates five types: spontaneous MI, MI secondary to an ischaemic imbalance, cardiac death due to MI, MI associated with a PCI, and MI associated with CABG.[57] Spontaneous MI would be the appropriate classification if an individual had CAD, formed a thrombus, and suffered an MI.[57] In contrast, the classification of MI secondary to an ischemic imbalance is used when CAD is not the cause of a thrombus and restricted blood flow, and some other condition causes the blood flow impairment, such as a coronary artery vasospasm.[57]

In addition to the five types of MI, an individual can be diagnosed with acute coronary syndrome (ACS) when the individual initially presents with symptoms of an MI or if the severity of the individual's symptoms worsens.[3] Myocardial ischemia can result in stable angina pectoris, but it can also cause ACS, which is subdivided into unstable angina pectoris, non-ST-segment elevation MI (NSTEMI), and ST-segment elevation MI (STEMI).[3] The characteristics of the thrombus differ for the classifications of ACS, where unstable angina pectoris and NSTEMI usually involve a thrombus that is incomplete, dynamic, or absent, and an occlusive

thrombus is usually present with STEMI.[9] This relates to the severity of the diagnosis: STEMI correlates with cardiomyocyte death from an occlusive thrombus; acute occlusion or incomplete occlusion correlates with NSTEMI; and even less severe occlusion correlates with unstable angina pectoris.[9]

While NSTEMI and STEMI both present with clinical symptoms and cardiac biomarker changes (i.e., increase in cardiac troponin in the blood) that are suggestive of a cardiomyocyte/myocardium death, a 12-lead electrocardiogram (ECG) can be used to determine if the ST segment of the cardiac cycle is elevated.[3] This is how the distinction between NSTEMI and STEMI is made; NSTEMI is not typically associated with an elevated ST segment, whereas STEMI is associated with an elevated ST segment .[3] Furthermore, clinical symptoms can also be the same for unstable angina pectoris, however a normal ECG may (i.e., no changes in the ST segment) exist and there is no elevation of cardiac biomarkers (i.e., cardiac troponin) indicating myocardium death.[3]

Alternatively, a health complication that manifests with end-stage CAD (with or without the occurrence of an MI) is heart failure accompanied by left ventricular systolic dysfunction.[9] The progressive disorder of heart failure originates when damage to the myocardium is induced.[3,9] Tissue damage experienced from myocardial ischemia reduces the heart's contractibility, therefore the heart tries to adapt by modifying the left ventricle (e.g., left ventricle hypertrophy) to maintain pumping capacity and systolic function, but there is ultimately impaired ventricle filling and emptying.[3,9,58] Notably, the presence of diastolic dysfunction coexists to some extent with systolic dysfunction.[9] The cardiovascular system puts forth

adaptations (e.g., blood volume, vascular, neurohormonal) in an attempt to maintain cardiac output, however these compensations are not entirely efficient and over time the disease progresses.[9]

Moreover, heart failure can be classified in terms of ejection fraction. Firstly, there is heart failure with a preserved ejection fraction (HFpEF), where the left ventricle can eject 50% or more of the blood it is supplied.[3] Secondly, there is heart failure with a reduced ejection fraction (HFrEF), where the left ventricle ejects less than 40% of the blood it is supplied.[3] Notably, heart failure with a mid-range ejection fraction (HFmrEF) is where the left ventricle can eject 40-50% of the blood it is supplied.[3] It is important to note that CAD (i.e., impaired blood flow or an MI) is the primary cause of heart failure in industrialized countries.[3] Moreover, CAD accounts for more HFrEF than HFpEF cases, whereas HFpEF often results from systolic hypertension.[59,60]

Previously, acute heart failure was thought to be part of the progression of heart failure, but it is now recognized as its own disorder.[3] Generally, the diagnosis of acute heart failure is applied when an individual requires immediate medical attention due to the exacerbation of heart failure symptoms, whether the symptoms are reoccurring or appearing for the first time.[3] Despite the presence of the word “acute”, the exacerbation of the symptoms may happen over time, and eventually may be amplified enough to require medical attention.[3]

The myocardial ischemia and cardiomyocyte death experienced with MI can cause electrophysiological changes within the heart.[61] Consequently, cardiac arrhythmias can occur when the electrical activity of an atrium or ventricle is

irregular, negatively affecting the heart rate and cardiac output and potentially causing cardiac arrest if the electrical activity is not normalized.[62] If an arrhythmia causes the heart rate to be too slow, it is termed a bradyarrhythmia, whereas a heart rate that is too fast is labeled as tachyarrhythmia.[9] Arrhythmias, especially those related to the ventricles, are frequently associated with the myocardial ischemia experienced with CAD, and MI.[9] Ischemic tissue and the production of scar tissue after MI can block electrical propagation in the heart causing the electrical impulse to reroute itself around the barrier (i.e., the ischemic tissue and scar tissue), which is known as re-entry and is most often associated with tachyarrthymias.[9] Ventricular arrhythmias such as ventricular tachycardia are common after an MI and can progress into ventricular fibrillation, and potentially sudden cardiac death.[9] Arrhythmias known as “heart blocks” can result from ischemic cardiomyocyte damage as well and involve the atrioventricular electrical propagation being impaired.[9]

Sudden cardiac death is the most severe consequence of an MI, heart failure or a cardiac arrhythmia.[3] Sudden cardiac death (i.e., cardiac arrest) has been defined by Zipes and colleagues[3] as “natural death from cardiac causes heralded by abrupt loss of consciousness within one hour of the onset of an acute change in cardiovascular status”. Overall, the cause of death is related to cardiac dysfunction, is unexpected, rapid, and considered natural.[3]

### 1.1.6 Surgical Interventions Associated with Coronary Artery Disease

Surgical interventions are often required for CAD. If an individual suffers from CAD, PCI (please refer to section 1.1.4) can be performed to mitigate the

presence of plaque in the arteries to relieve symptoms and improve the probability of survival.[3,63] The coronary arteries are accessed by inserting a catheter through the femoral, brachial, or radial artery.[3] Once the catheter has reached the affected coronary artery, different methods are used to expand (e.g., balloon angioplasty) or support via stents (e.g., bare-metal or drug-eluting) the coronary lumen or to remove the plaque (e.g., coronary atherectomy).[3,63]

Depending on the complexity of the diagnosis, CABG (please refer to section 1.1.4) may be the more appropriate revascularization procedure.[20] The gold standard for CABG is to induce cardiac arrest in the individual, then conduct an on-pump CABG to control hemodynamics while operating.[64] On-pump CABG involves cross-clamping the aorta and bypassing the cardiopulmonary system to control hemodynamics.[65] Alternatively, CABG can be performed on a beating heart, which is known as off-pump CABG and uses tactics to minimize cardiac motion.[64] A median sternotomy is the most efficient incision technique to access the heart; however, other methods have evolved such as the less invasive endoscopic method with robot assistance.[64] As the name implies, new routes for arteries or veins are grafted to bypass the affected coronary arteries and improve blood flow.[64] CABG is recommended to improve survival when there is greater than or equal to 50% stenosis in the left main coronary artery however, there are exceptions for when PCI may be preferred.[63,64] CABG is also recommended to improve survival when greater than or equal to 70% stenosis occurs in three major coronary arteries, or when it occurs in one major coronary artery plus the proximal left anterior descending artery.[63,64]

When there is greater than or equal to 70% stenosis, PCI or CABG can improve survival for individuals with sudden cardiac arrest who are suffering from ventricular tachycardia due to myocardial ischemia.[63,64] Additionally, when an individual is expected to positively respond to revascularization, and if other medical interventions have not relieved unacceptable levels of angina, PCI or CABG can be performed when 1 or more coronary arteries have greater than or equal to 70% stenosis to improve symptoms.[63,64] PCI or CABG can also be performed to treat ACS.[63,64,66] In individuals with unstable angina pectoris and NSTEMI, the purpose is to relieve symptoms, reduce the occurrence of an MI, and prevent death.[63,64,66] Moreover, in individuals with STEMI, PCI and CABG can also be performed to reduce complications and death.[63,64,66] Overall, the choice between PCI and CABG to treat CAD and its complications is specific to the individual with many factors to be considered.[63,64,66]

If the issue concerns the electrical function of the heart, an implantable electronic device can be inserted subcutaneously below the clavicle.[12] To maintain atrioventricular synchrony, a permanent pacemaker is implanted with leads placed in the right atrium and right and/or left ventricle to sense and restore electrical activity.[12] Comparatively, an implantable cardioverter- defibrillator has leads that innervate the heart transvenously to detect fatal ventricular tachyarrhythmias and regain proper pacing, or provide defibrillation if necessary.[12]

Ultimately, in instances where surgical interventions do not relieve symptoms and end-stage heart failure is present, an orthotopic heart transplant may be required.[12]

### 1.1.7 Pharmacotherapy Associated with Coronary Artery Disease

The administration of cardioprotective medications can be effective in preventing and treating CAD as well.[20] Beta blockers are a class of drugs that lower heart rate and blood pressure levels to help treat CAD.[20] Angiotensin-converting enzyme inhibitors and angiotensin-receptor blockers are other classes of drugs prescribed for CAD to dilate the arteries.[20] By dilating the arteries, angiotensin-converting enzyme inhibitors and angiotensin-receptor blockers lower systemic blood pressure and the pressure in the heart, preventing the heart from overworking.[20] Consequently, the heart can recover from an MI, there is a decreased risk for arrhythmias, and cardiac dysfunction due to heart failure is improved.[20] Additionally, the class of drugs known as platelet inhibitors limit platelet aggregation and decrease inflammation, therefore this class of drugs may be prescribed for CAD treatment.[20] Since this class of drugs prevents the formation of a thrombus, they are usually prescribed after a PCI to prevent a thrombus from forming in a stent.[20] Another vital class of drugs for prevention and treatment of CAD are statins, which lower blood cholesterol levels, decrease inflammation, and promote the thickening of the fibrous cap; all important approaches to preventing plaque disturbance and its resulting consequences.[20]

### 1.1.8 Lifestyle Interventions for Coronary Artery Disease

While surgical interventions and pharmacotherapies are prevalent in cardiology, it has been apparent for many years that the field should be integrative by emphasizing disease prevention and lifestyle interventions to improve medical care and outcome.[3,67] The terms integrative cardiology or preventive cardiology

describe this ideology of care and are greatly shaped by the CVD risk factors established by the Framingham Heart Study.[3,67] Essentially, the main objective of integrative cardiology is the prevention of disease, where the care provided models guidelines, but individuals also possess control to develop goals and therapeutic plans in synergy with healthcare providers.[3] Integrative cardiology exceeds traditional standards of care in cardiology by emphasizing therapeutic plans that incorporate lifestyle interventions to yield the greatest outcomes for individuals by reducing the burden of CVD risk factors.[3]

Cardiac rehabilitation (CR) is an ideal example of integrative cardiology.[68] CR is a secondary prevention strategy delivered by a multidisciplinary team of health professionals, with a focus on lifestyle interventions (e.g., tobacco cessation, exercise training, and nutritional counselling) to manage the modifiable risk factors associated with CVD and ultimately CAD.[69] CR aims to improve the overall well-being of participants, including physical, psychosocial, and vocational success.[17,22]

## 1.2 Cardiac Rehabilitation

### 1.2.1 Benefits of Cardiac Rehabilitation

A recent Cochrane Systematic Review and meta-analysis (63 randomised controlled trials; 14,486 participants) provided evidence that exercise-based CR (primarily aerobic training; median intervention length of six months), compared to usual care (standard medical care with no form of exercise prescription and guidance), reduced cardiovascular mortality and the overall risk of hospital admissions.[68] However, these benefits did not translate into a reduction in all-

cause mortality.[68] Due to the variance in health-related quality of life (HRQoL) measures, a meta-analysis was not conducted on this parameter, but in those studies including HRQoL there was evidence of improvement following exercise-based CR participation.[68]

It is important to note that the trials included exercise-only interventions and interventions employing more comprehensive secondary prevention strategies (i.e., exercise, educational, and psychosocial components).[68] The level of supervision varied (i.e., unsupervised or supervised) as did the location of the interventions (i.e., inpatient, outpatient, community-based, or home-based).[68] The incorporated trials were primarily located in Europe (59%; 37 studies) with nine trials conducted in the United States and three in Canada.[68] Furthermore, less than 15% of the participants were women with the sample primarily representing younger men post-MI or revascularization surgery.[68]

Recently, the aforementioned work was scrutinized for its inclusion of out of date trials. Therefore, Powell and colleagues[70] revised the Cochrane Systematic Review and meta-analysis by Anderson and colleagues[68] and focused on more recent trials to include only those occurring in the last two decades to represent the time period of surgical and pharmacological advancements for CVD. Similar to Anderson and colleagues[68], exercise-based CR did not reduce all-cause mortality.[70] However, in contrast to Anderson and colleagues[68], reduction in CVD mortality was no longer significant, but the authors did note a minimal reduction in hospital admissions.[70]

These findings were met with resistance from the international CR community, with investigators around the world questioning the legitimacy of the work. An editorial was published in response to Powell and colleagues[70] and implied that Powell and colleagues' search tactics did not guarantee that the included trials addressed all core components of CR, and in modern CR it is exercise in conjunction with the other core components that yields the greatest benefits.[71] It is also important to understand the context in which the exercise interventions were applied because many factors (e.g., personal, environmental, organizational, professional) can influence the measured outcomes, and perhaps certain components of the intervention are not as beneficial in specific circumstances.[71]

Very recently, a systematic review of CR meta-analyses (published prior to 2012) of individuals with CAD or heart failure was conducted to determine the statistical and clinical (e.g., minimal important difference in a domain that an individual considers important and that would encourage clinicians to recommended CR as part of the individual's treatment plan) evidence for CR outcomes.[72] The meta-analyses included mostly centre-based supervised exercise interventions (87%; thus home or telemedicine based CR was underrepresented), and typically included aerobic and/or resistance training, with or without psychosocial and/or educational interventions.[72] It was determined that the majority of the studies reported statistical as opposed to clinical significance, therefore lacked practical or clinical importance (e.g., minimal important difference), which is important to determine when encouraging CR referral and

enrollment by clinicians and their patients, respectively.[72] Additionally, similar to the previously mentioned studies, there was little impact of CR on all-cause mortality, but a reduction in cardiovascular mortality was observed.[72] Future research is warranted to determine the impact of modern medical management on all-cause mortality and the potential confounding role in CR-driven benefits.[72]

Nonetheless, exercise as a cornerstone component for CR has demonstrated many clinical benefits. Increased cardiorespiratory fitness from aerobic training in CR is correlated with a reduction in blood pressure, visceral adiposity and systematic inflammation, and improved insulin sensitivity, endothelial function and psychological stress.[73] Moreover, a combination of resistance and aerobic training in CR results in a greater decrease of body fat percentage and greater increases in quality of life, maximal oxygen consumption, fat-free mass, and both upper and lower body strength, compared to aerobic training alone.[74]

In a related systematic review and meta-analysis, investigators sought to expand the exercise only focus and included recent randomised controlled trials that involved interventions beyond exercise to incorporate other key secondary prevention strategies as well.[75] van Halewijn and colleagues[75] determined that the risk of MI as well as cerebrovascular events were reduced by comprehensive CR. Comparable to Anderson and colleagues[68], CR did not decrease all-cause mortality, but did reduce cardiovascular mortality.[75] An important finding of this work was the observed relative reduction in all-cause mortality with cardiac rehabilitation programs (CRPs) that addressed six or more risk factors, compared

to those that addressed less than six risk factors.[75] This finding supports the previous work of Rauch and colleagues[76], emphasizing the importance of a multi-component CRP for CVD treatment.[75] As such, there is a demand for further research regarding the effect of individual CR components and the collective effect on clinical outcomes.[77,78]

### 1.2.2 History

CR has been evolved over the last century. In the 1860's immobilization was considered the most valuable treatment for MI because it was presumed to allow the heart to recover naturally.[79] Accordingly, in the 1920's individuals who suffered from an MI were urgently confined to bed rest as recovery of the heart was still presumed to be correlated with ample physical rest.[80,81] The optimal duration of bed rest was at least a month and prolonged for symptomatic individuals, whose ordinary lives were encouraged to be delayed if required.[80] Thus, bed rest remained the predominant rehabilitation treatment for MI, enduring for nearly four decades.[82]

During the 1950's the validity of prolonged bed rest as a treatment for MI was disputed. Accumulating evidence suggested that it was unnecessary, as well as potentially detrimental to an individual's physical and mental health.[83,84] With this new stance, chair treatment or the "cardiac chair" began to evolve, which was predicted to be a superior method for resting the damaged heart.[84] More specifically, within two days of an MI, individuals were transferred to a chair and later returned to bed when fatigue occurred.[84,85] Individuals eventually remained in the chair for the better part of the day and around the third or fourth week the

individuals began to take steps.[84,85] This new form of treatment overthrew the impression that heart rupture or death would occur if the individual did not remain on bed rest.[79] In reality, when compared to bed ridden individuals, those who underwent chair treatment during hospitalization had increased physical and psychological health, demonstrating a promising rehabilitation process that included mobilization.[85–87] Eventually, it was demonstrated that participation in endurance activities such as swimming and hiking was “cardioprotective” and “rehabilitative”, revealing the necessity of not only mobilization, but exercise of all intensities in the rehabilitation process of the individual.[88]

The goal of rehabilitation for individuals with cardiac events or conditions expanded beyond simply having the individuals discharged from the hospital, but also focused on equipping the individuals to excel in everyday life, including vocationally.[87,89] The early objective of rehabilitation was to simply regain regular physical activity and independence.[90] However, addressing all aspects of the individual’s life (e.g., physical and psychological well-being) and not solely economic success was said to allow an individual to live a fulfilled life.[87,89] This new model of rehabilitation involved a non-hierarchal multidisciplinary team that provided an individualized program to the most significant member of the team, the individual with a cardiac event or condition.[87,89] In essence, CR expanded beyond only exercise as treatment for the individual to encompass other secondary prevention strategies like those found in the modern CRP, such as health behaviour change and education, cardiovascular risk factor management, and cardioprotective therapies.[22,91]

### 1.2.3 Eligibility

Recently, an international organization, the International Council of Cardiovascular Prevention and Rehabilitation was founded to create a more homogenous model of CR around the world.[92] At this time, the International Council of Cardiovascular Prevention and Rehabilitation is too new to provide global CR guidelines, however the council endorses the recent review of international CR guidelines by Price and colleagues.[92,93]

As indicated by Price and colleagues[93], the eligibility for CR is relatively standard throughout the world with a few nuances between countries: MI, unstable angina, stable angina, asymptomatic CAD, revascularisation procedures, cardiac valve surgery and other cardiac surgeries, pacemaker or implantable cardioverter-defibrillator insertion, atrial fibrillation, chronic heart failure, cardiomyopathy, rheumatic and congenital heart disease, cardiac transplantation, peripheral arterial disease, pulmonary hypertension, post cerebral vascular disease, and individuals with a high risk of developing CVD.

If the focus is narrowed to specific countries, in Canada, the Canadian Association of Cardiac Rehabilitation or more recently named, the Canadian Association of Cardiovascular Prevention and Rehabilitation (CACPR) is responsible for national CR guidelines, including eligibility criteria, with provincial organizations such as CorHealth Ontario (previously the Cardiac Care Network (CCN)) supplying the latest guidelines. In Canada, individuals diagnosed with an MI or ACS, chronic stable angina pectoris, or heart failure, or who have undergone revascularisation procedures (e.g., PCI or CABG), cardiac resynchronization

therapy, cardiac valve surgery, or a cardiac transplantation are most commonly referred to CR.[22] However, the provincial level guidelines in Ontario, while following the national referral eligibility recommendations, also suggest that if CVD risk factors (e.g., hypertension, dyslipidemia) are prevalent then an individual should be referred to CR even if the individual has not yet had a CVD event.[91]

In the United States, eligibility for referral to CR is nearly identical to Canadian guidelines, with the exception that the United States guidelines do not mention a referral to CR following cardiac resynchronization therapy, or if CVD risk factors are prevalent but a CVD event has not yet occurred.[17,94,95] The association in the United States that provides national CR guidelines is the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR). Likewise, the American Heart Association (AHA) and the American College of Cardiology (ACC) are also legitimate resources.

### 1.2.4 Inpatient Cardiac Rehabilitation

The progression of CR is standard throughout the world, beginning with a hospitalization for a coronary event, followed by a recovery period, and then on-going rehabilitation and maintenance, although slight nuances may exist within each component.[93] There are three common phases of CR: inpatient CR, early outpatient CR, and long-term outpatient or maintenance CR.[22] After the stabilization and treatment of an acute coronary event the initiation of CR may commence with inpatient CR, additionally, the CACPR suggests that inpatient CR may commence before procedures such as PCI and CABG if these procedures are prearranged.[17,22]

The preamble to inpatient CR is a chart review and a detailed interview to assess the individual's medical history before beginning the core elements of inpatient CR, including physical activity progression and education.[17] The rate of progression for mobilization and physical activity will be dependent on each individual's diagnoses with some advancing more rapidly than others.[17] When an individual shows a willingness to learn then education on CVD risk factor management and self-care should promptly begin focusing on the individual's personal interests, but always addressing information related to their safety as well.[17]

The qualified individual who delivers inpatient CR may be a nurse, occupational or physical therapist, exercise specialist, or another staff member who specializes in CR.[17] The location of implementing inpatient CR can differ; most often taking place in an individual's room or care unit, mobilization and physical activity can also occur in hospital hallways or in inpatient exercise rooms.[17] In some instances, there may be a specific room dedicated to inpatient CR where individuals can undergo assessments, educational sessions and mobilization activities to become prepared for discharge, and referral to early outpatient CR.[17] The CACPR and AACVPR concur it is the responsibility of the inpatient CR health professional to create a discharge plan for individuals, educate the individuals about early outpatient CR, and refer individuals to early outpatient CR before hospital discharge.[17,22]

### 1.2.5 Referral Process

Referral to early outpatient CR is the initial step for outpatient CR enrollment, incorporating an order for CR based on the individual's medical record, a conversation between a health professional and the individual about CR, and finally a CRP receiving information regarding the referral.[96] The CACPR and AACVPR both highlight the importance of health professionals endorsing early outpatient CR enrollment for eligible inpatients to encourage participation.[17,22] Furthermore, if within the previous year an individual received an eligible diagnosis for referral to CR in the outpatient setting, a physician or another cardiac health professional is responsible for referring the individual to early outpatient CR if the individual has not previously participated.[17,22]

In Canada there is a benchmark of 30 days to enroll an inpatient in early outpatient CR after hospital discharge, and in the province of Ontario, within two weeks of receiving the referral, it is the CRP's responsibility to contact the individual to schedule an intake appointment.[91,97] Similarly, in the United States it is recommended that 1 to 3 weeks after inpatients are discharged from the hospital early outpatient CR should commence, with a benchmark for time to enrollment of 21 days post hospital discharge.[17,95]

The traditional or "usual" procedure for referral to CR is non-systematic and relies on the discretion of the physician to recommend CR and complete the referral.[98,99] However, it is highlighted by the CACPR and AACVPR that automatic referral procedures should be implemented to maximize referral rates, rather than usual referral procedures.[17,22] In fact, it has been demonstrated that individuals

have a greater probability of being referred to CR when automatic referral procedures are employed.[98–100] Automatic referrals are systematic and may involve electronic medical records, where a referral to CR is the default on order sets that healthcare professionals must uncheck, or a referral may be automatically sent to the CRP according to codes entered into a medical record to describe the individual's health status.[100,101] Additionally, an automatic referral may be paper-based and included with hospital discharge order sets, then faxed to CR sites after completion.[100,101] Notably, switching from manually faxed paper forms for automatic referral to an electronic system has been shown to increase the number of inpatient referrals by 17-fold.[102]

Unfortunately, referral rates in both Canada and the United States remain suboptimal, but it has been recognized that strategies need to be employed to drastically increase referrals to CRPs.[96,103] One of the key barriers for referrals is the referring physician, who may pose as a hinderance for various reasons, such as lack of endorsement or educated promotion of CR to patients.[104–106]

Fortunately, automatic referral procedures in conjunction with a liaison to discuss CR with the individual before discharge can increase referrals rates to 85.8%, compared to 70.2% for only automatic referral procedures.[99] This emphasizes the importance of automatic inpatient referral systems and liaisons to educate and refer an individual to outpatient CR, and the combination of these two strategies to overcome barriers such as lack of physician endorsement to improve referral rates to early outpatient CR.[96,99]

### 1.2.6 Barriers to CR Participation

Even if optimally referred, there are many barriers that prevent individuals from participating in CR. Thus the utilization and completion rates for CR in both Canada and the United States remains suboptimal, requiring substantial improvement.[96,103] Specific cohorts of individuals are less likely to participate in CR including women and older individuals.[107–112] It has also been suggested that socioeconomic status and race or ethnicity influence participation rates, where individuals with a lower socioeconomic status (i.e., lower education, unemployed, lower income) and who identify as a minority are less likely to engage in CR.[107–110,113,114] Additionally, individuals with more comorbidities, and those who have been referred for an indication other than CABG are less likely to participate. [107–110,112] Moreover, studies examining these factors provide contrasting results or were not sufficiently comprehensive and hence warrant further consideration in the modern era of CR.[109]

Furthermore, individuals may not participate in CR due to accessibility issues (e.g., transportation and travel distance), time availability, and the cost of CR, the latter of which is particularly relevant in countries such as the United States.[107,115] Conclusively, the CRP itself can be restrictive as well if services are limited due to facility or financial constraints.[103]

Strategies have been suggested by Ades and colleagues[96] to overcome these barriers and improve utilization and completion rates for CR. For instance, offering gender-tailored programming, reducing the financial expense for individuals, providing flexible hours of programming (e.g., after work and weekend

hours), evaluating performance measures to improve services offered, and incentives for participating (e.g., motivational, financial) are a few of the strategies proposed to improve utilization and completion of CR.[96]

### 1.2.7 Intake Assessment

Following a referral to early outpatient CR, initial contact by the CRP, and the completion of an intake appointment, an intake assessment including a medical and physical evaluation is common internationally prior to beginning early outpatient CR.[93] Within the Canada and the United States, guidelines regarding the intake assessment are similar.[17,22,91] Moreover, the data collected during the intake assessment is important to revaluate periodically throughout the duration of early outpatient CR and at program completion to monitor progress.[17,22]

Using information obtained during the intake session, together with other clinical variables (e.g., cardiorespiratory fitness, metabolic fitness), an intake assessment determines the participant's risk for another cardiac event and is especially relevant during the exercise component of CR.[17,22,91] It is preferred that the medical and physical evaluations be performed by a physician or other health professional with CVD experience.[17,22] Following the intake assessment, an individualized care plan can be developed that aligns with the participant's goals and provides self-managing strategies to reduce the participant's risk of CVD.[17,22,91]

Firstly, the medical history should focus on the status of the participant's CVD, including the participant's risk factors and how the risk factors are being managed to allow for the appropriate lifestyle modification

recommendations.[17,22,91] The medical history should include past and present CVD symptoms, diagnoses, hospitalizations, and surgical procedures, as well as medications, risk factors for atherosclerotic disease progression, family history, and comorbidities.[17,22,91]

Additionally, information should be recorded on dietary content and eating habits, sleep habits, physical activity or exercise patterns, alcohol consumption, emotional and psychosocial health, and tobacco use.[17,22,91] It is also advantageous to address demographic information and other influences on health that may pose as a barrier to CR participation such as sex, age, race or ethnicity, socioeconomic status (i.e., level of completed education, employment circumstances, financial situation), and social support.[17,22,91]

Secondly, the physical evaluation should assess the following: vital signs (e.g., pulse rate and blood pressure), anthropometrical measurements, cardiovascular status, respiratory status, musculoskeletal status, procedure-related issues, and function of the lower extremities.[17,22,91] Laboratory results including a lipid profile, glucose and glycosylated hemoglobin (HbA1c) measurements, and a resting 12-lead ECG are essential components of the intake assessment as well.[17,22,91]

If the medical and physical evaluations deem it safe for a participant to exercise, an exercise stress test protocol will be conducted to estimate the participant's cardiorespiratory fitness level (i.e., functional capacity; maximal oxygen consumption [$VO_2$]).[17,22] An ECG-monitored graded exercise test can be used as a functional assessment tool to determine cardiorespiratory fitness, and

therefore help administer a safe and individualized exercise program.[17,22,91] Very recently, the AACVPR stated that the most accurate exercise prescription can be recommended when a symptom-limited graded exercise test is conducted prior to CR participation, which coincides with CACPR recommendations.[22,116] Nonetheless, an exercise protocol should be determined on an individual basis as there are many protocols available to measure both submaximal (i.e., to estimate maximal $VO_2$ by use of equations) and maximal $VO_2$ depending on individual factors (e.g., disease status, age, estimated physical fitness level).[3] However, although not as validated, another assessment such as the six-minute walk test can be used when graded exercise tests are unavailable or for participants with other limiting factors.[17,22,91] Additionally, metabolic fitness (i.e., the effect of CVD risk factors) can be predicted by using measures such as the Framingham risk assessment tool.[17,22]

### 1.2.8 Outpatient Cardiac Rehabilitation

After completion of the intake assessment, the early outpatient CR phase commences. The standard duration is six months in Canada, with an average of two onsite sessions per week.[22] While Canada does have a publicly funded health care system, early outpatient CR funding varies by province.[103,117] Within Ontario the fee for early outpatient CR is typically covered by the Ontario Ministry of Health and Long-term Care following the success of a 2001 CR pilot project in Ontario that demonstrated the value of CR.[118]

In the United States, 36 onsite sessions is the standard, commonly three times per week for a total of three months of early outpatient CR, which may be

publicly funded (e.g., Medicare for participants greater than 65 years of age) or privately funded (e.g., purchased health care insurance), however, participants may still need to provide co-payments for each visit even if insured.[17,96,119,120] Evidently, if participants do not qualify for public funding or hold private funding, the participant may pay for CR entirely out-of-pocket.

Once an individual is enrolled in early outpatient CR a customized, multifaceted, evidence-based intervention will be designed to meet the individual's needs.[17,22] In both Canada and the United States, the core components of outpatient CR are: intake assessment, risk factor modification and health behaviour interventions (nutritional counselling, lipid management, weight management, hypertension management, diabetes management, adherence to appropriate pharmacotherapy, tobacco cessation, psychosocial management, and physical activity counselling), and exercise training.[17,22]

In Canada, the CACPR takes it one step further to also include, a systematic referral process, program adaptations for underserved populations, growth of self-management techniques for participants, and leisure time activities as core components.[22] The other core components stated by the CACPR are programs to assess outcomes, performance measures, quality improvement, and professional development to constantly improve program delivery.[22]

The province of Ontario has an even more comprehensive description, stating three core CR components of: health behaviour change and education, cardiovascular risk factor management (physical activity, nutrition, tobacco use,

psychological/psychosocial health, hypertension, dyslipidemia, dysglycemia), and lastly cardioprotective therapies.[91]

While all the components mentioned by the CACPR are important to address, the AACVPR and CCN provide more up to date, simplistic core components, and address all other components mentioned by the CACPR elsewhere in the published guidelines. Nonetheless, the overall goal of outpatient CR is to provide lifestyle management counselling and education to encourage behaviour changes that may prevent a secondary cardiac event.[121]

The core components of CR are fulfilled by having a multidisciplinary team of staff members.[17,22] A medical director who is a physician is required, but other key personnel may include: registered nurses, exercise specialists, exercise physiologists, physical therapists, respiratory therapists, registered dietitians, mental health professionals (e.g., psychologist, social worker, or psychiatrist), health educators, occupational therapists, vocational rehabilitation counselors, clinical pharmacists, cardiovascular technicians, and other physicians.[17,22] The multidisciplinary team allows for all-encompassing lifestyle alterations that will hopefully result in favourable and permanent behaviour changes.[122]

Three main models of early outpatient CR delivery exist. The most traditional model involves supervision by the staff members previously mentioned, and the location is centre-based within the community (e.g., located in a hospital physiotherapy centre or university gymnasium).[17,91,123] Centre-based deliverance of CR is appropriate for high-risk participants (as determined previously through risk stratification protocols) who require supervised exercise training.[22]

Nevertheless, alternative models of early outpatient CR have been introduced to increase participation rates.[17,22,123]

Two alternative or complementary models to centre-based CR are home-based and hybrid programming.[17,22] Once deemed safe, following risk stratification, participants can engage in home-based CR, which involves the majority of the participants' exercise training completed without direct supervision.[17,22] A home-based model limits the amount of on-site sessions required, but still maintains communication with the participant (e.g., telephone calls, regular mail) and provides follow-ups with an exercise specialist to monitor the participant's exercise prescription.[22]

The hybrid model serves as a transition from centre-based to home-based CR, involving both on-site (at least once per week) and home-based exercise training to monitor a participant's safety.[22] In both the home-based and hybrid model, the CR components beyond exercise training are still addressed, and thus the models serve as alternative outpatient CR models to overcome participation barriers (e.g., transportation, work commitments).[22,124] It has been demonstrated that there are no significant differences for total mortality, exercise capacity, or HRQoL between these complementary models and centre-based CR, emphasizing the potential of the complementary models to increase participation rates.[123–125]

### 1.2.9 Maintenance Cardiac Rehabilitation

The maintenance phase, recommended internationally, follows the early outpatient phase for participants who want to continue managing CVD risk

factors.[17,22,93] The maintenance phase is comparable to the early CR phase, where the CRP is most often located within a hospital or elsewhere in the community.[17,22] Patients continue to complete an individualized secondary prevention program; however, there is usually less interaction with CR staff members than that received during initial CR programming.[17]

### 1.3 Cardiac Rehabilitation Exercise Prescription

Exercise training is a core component of CR around the world.[93] In general, exercise-based CR is considered safe because of the intensive risk factor stratification that occurs in the previously mentioned intake assessment.[17,22] Moreover, it is safe in both the early outpatient and maintenance phase of CR.[126]

Overall, the frequency, intensity, time, type, volume, and progression of exercise should be included in an exercise prescription for all CR participants.[116] To ensure participants are fully experiencing the benefits of CR, a participant's exercise prescription must be individually progressed to continuously improve cardiorespiratory fitness and muscular strength, while avoiding health complications.[116] However, only one factor of FITT (frequency, intensity, time, type) should be progressed at a time, and for aerobic training time or duration is commonly increased first.[116] A progressive exercise program is appropriate for participants with severe CVDs and the elderly, as long as the participants have been approved to engage in exercise.[116] There are many factors to consider when progressing a participant's exercise prescription, especially the expectations and preferences for personal goals that the participant possesses.[116]

Regardless of a participant's baseline level, the CACPR mentions that all exercise prescriptions should commence with a 5 to 10-minute warm-up at an intensity of 20% to 35% of the participant's heart rate reserve (resting heart rate is subtracted from heart rate max (HRmax)), and conclude with a cool-down of the same length, but at 60% or less of the participant's HRmax.[22] Unlike the CACPR, the AACVPR does not provide general recommendations for a warm-up and cool-down, but instead provides guidelines for specific populations such as those with heart failure and cardiac transplantations.[17]

The CACPR alludes to including flexibility training in the exercise prescription, but lacks a frequency and intensity, whereas the AACVPR suggests two or three non-consecutive days per week at an intensity that is painless.[17,22] However, the CACPR does suggest holding static stretches for 15 to 60 seconds and completing more than four repetitions per exercise for each major muscle tendon group.[22] Additionally, partner assisted neuromuscular facilitation techniques are recommended by the CACPR and are to be performed by holding a contraction for six seconds, shadowed by a 10 to 30 second assisted stretch.[22] Similarly, the AACVPR recommends focusing on static stretches of the lower back and thighs with a gradual increase in duration by holding each static stretch for 30 to 90 seconds, for 3 to 5 repetitions.[17]

### 1.3.1 Aerobic Training

In early outpatient CR, aerobic training is predominant with intensity being the most impactful factor targeted for improvement.[116] To determine aerobic

training capabilities (i.e., cardiorespiratory fitness) a symptom-limited graded exercise test is performed to establish a safe exercise prescription.[17,22]

The CACPR recommends aerobic training 3 to 5 days per week for 20 to 40 minutes per session at 40% to 85% of heart rate reserve.[22] More recent provincial guidelines from the CCN suggest partial recommendations for aerobic training, stating it should be prescribed 5 to 7 days per week incorporating at least 30 minutes per session.[91] Comparably, the AACVPR recommends aerobic training most days of the week (i.e., 4 to 7 days per week) for 20 to 60 minutes per session, at 40% to 80% of HRmax, metabolic reserve or maximal oxygen consumption.[17]

Aerobic exercise training may be accomplished on electronically designed devices (e.g., treadmills or ergometers) or in locations that allow spacious activities such as walking or cycling, either indoors or outdoors.[17] Essentially, rhythmic exercises that incorporate large muscle groups are recommended to sustain a healthy body weight through an increase in caloric expenditure during these activities.[121]

### 1.3.2 Resistance Exercise Training

The CACPR, AACVPR, and CCN recommend resistance training in conjunction with aerobic training.[17,22,91] To determine resistance training capabilities, the gold standard is a one-repetition maximum (RM) test for each resistance exercise that will be completed during the exercise program.[116] The CACPR and AACVPR both mention a 1RM test (maximal weight an individual can lift once) to determine baseline musculoskeletal fitness, but the protocol should be implemented conservatively and monitored (e.g., ECG, heart rate, blood pressure,

and rating of perceived exertion (RPE)).[17,22] Additionally, the multiple RM (6RM to 15RM; maximal weight an individual can lift 6 to 15 times) is also recommended by the AACVPR as a less stressful protocol compared to the 1RM.[17]

The resistance training guidelines for CR recommend a frequency of 2 to 3 days per week (the AACVPR specifies non-consecutively) including 1 to 3 sets of exercises encompassing both the upper and lower body.[17,22] The importance of breathing properly and not breath holding during resistance training is emphasized in the guidelines.[17,22] The CACPR suggests 12 to 15 repetitions of 6 to 10 different exercises at a RPE of 11 to 15 (Borg 6 to 20 scale), and similarly, the AACVPR suggests 10 to 15 repetitions of 8 to 10 different exercises at a RPE of 11 to 13 without severe fatigue.[17,22] Additionally, the CACPR suggestions that intensity can be quantified as 30% to 40% of a participant's 1RM for upper body exercises, and 50% to 60% of the participant's 1RM for lower body exercise.[22] The CACPR and AACVPR agree that resistance (i.e., weight) can be increased by approximately 5% once the participant can comfortably perform the prescribed repetitions (the AACVPR specifies the upper limit of the repetition range).[17,22] Many types of exercises can be performed such as those utilizing resistance bands, free weights, or weight machines.[17]

### 1.3.3 Exercise Monitoring

The degree of monitoring during exercise is determined based on pre-programming risk stratification and clinical judgement.[17,22] ECG, heart rate, blood pressure, and RPE (Borg Scale) are examples of variables monitored during exercise in CR.[17,22]

The level of ECG-monitoring or telemetry (e.g., continuous to intermittent) that is required during exercise training can vary.[17,22] For instance, in Canada it is at the discretion of the medical director to determine the usage, type, and length of telemetry monitoring, whereas in the United States, it may be mandatory for insurance reimbursement.[17,22]

### 1.4 Performance and Quality Indicators

To ensure that involvement in CR remains safe for the participant, and to ensure maximum outcome, the CACPR and AACVPR state that it is necessary to evaluate performance measures periodically throughout program participation, especially before enrollment and at program completion (i.e., graduation).[17,22]

The performance or quality of a CRP can be measured with evidence-based indicators that ensure participants are receiving the best standard of care by the CRPs implementing and following validated CR recommendations.[95,97] More specifically, the Canadian Cardiovascular Society (CCS) implements evidence-based performance measures or quality indicators to evaluate the efficiency of CRPs in Canada.[97] The CCS established 30 quality indicators, and determined the "Top 5" quality indicators to be: three process indicators (percentage of eligible inpatients referred, number of days between receipt of referral at the CRP to enrollment, and percentage of enrolled individuals who received self-management education), one outcome indicator (percentage of CR participants who achieved a half metabolic equivalent increase in exercise capacity upon completion of the program), and one structure indicator (percentage of CRPs with an emergency response strategy).[97]

Comparatively, the AHA and the ACC recently released updated performance measures and quality measures to assist health professionals in the United States with evaluating the performance or quality of CRPs.[95] The AHA and the ACC have subtypes of quality indicators comprising performance measures and quality measures.[95] Performance measures are based off of scientific evidence and Class I clinical practice guidelines, therefore making performance measures appropriate to publicly report and be used for payment for performance programs.[95] Although quality measures are important factors to evaluate, they do not currently have the caliber of evidence to support the usage of quality measures as performance measures.[95]

The AHA and the ACC have established six performance measures: percentage of eligible referrals from an inpatient setting to CR, percentage of eligible referrals from an outpatient setting to CR, percentage of eligible exercise training referrals for heart failure from an inpatient setting, percentage of eligible exercise training referrals for heart failure from an outpatient setting, and percentage of CR enrollment both claims-based, and registry or electronic health records based.[95]

When comparing the “Top 5” quality indicators from the CCS to the performance measures proposed by the AHA and ACC, the only measure that overlaps is the percentage of eligible referrals from an inpatient setting to CR.[95,97] Evidently, governing bodies in Canada and the United States that provide national guidelines for performance and quality measures may not equally value the same measurements. The AHA and ACC seem to evaluate what would be considered

process quality indicators by the CCS, focusing on rates of referral and enrollment.[95] While the CCS does evaluate process quality indicators related to referral and enrollment rates, the CCS also evaluates other factors such as self-management education deliverance, exercise capacity changes, and the implementation of an emergency response strategy.[97]

Furthermore, when comparing the work from Grace and colleagues[127], who examined the Canadian Cardiac Rehab Registry (CCRR) (database for Canadian CRPs intake and discharge data for participants) and the work by Pack and colleagues[128], who examined the AACVPR database (database for program directors of verified AACVPR CRPs), differences are presented between the countries for important quality indicators. For instance, Grace and colleagues[127] estimated an average wait time of 84 days, which is much more than the wait time of 3 to 4 weeks (21 to 28 days) for 49% of the CRPs that Pack and colleagues[128] evaluated. In contrast, the results from the CCRR indicated a higher program completion rate of 90%, compared to 75% for the AACVPR database.[127,128] It is important to note the slight variation in definition of program completion (CCRR: some component of the CRP attended and a formal re-assessment conducted at the end of participation; AACVPR: each program followed a unique definition for program completion) between the two countries, but nevertheless comparing each country's strengths and weaknesses by examining performance measures or quality indicators is important to determine how to improve CR utilization.[127,128] This is significant considering CRPs in both Canada and the United States have yet to create a standard of care where all quality indicators are being fulfilled to

capacity (i.e., 100% quality), as demonstrated by Grace and colleagues and Pack and colleagues.[127,128]

When quality indicators are monitored, and strategies are carried out to increase quality indicator rates, promising improvements in CR utilization are found. For example, a CRP at the Mayo Clinic (Rochester, Minnesota, United States) progressively incorporated quality improvement projects and when analyzing data from more than 1000 participants, the CRP's participation rate was successfully increased.[129] More specifically, the CRP's two-year quality improvement project began by changing the program's recommendation for program duration to a full dose of 36 sessions for all participants in March 2010.[129] Secondly, an informational video on CR, shown before hospital discharge and at the first CR early outpatient session, was applied in November 2010.[129] Finally, a motivational program was incorporated into the early outpatient CR in July 2011, where participants were rewarded for attending sessions and staff were rewarded for high performance.[129] Participants received a specific prize (e.g., parking pass, T-shirt, tote bag) after every sixth session attended, and staff received similar prizes for accomplishing tasks and promoting participant success.[129] After the implementation of this quality improvement project, attendance for this CRP improved from 12 to 20 sessions per participant; in other words, there was a 40% improvement in attendance rates over a short two-year time frame.[129] Additionally, the number of participants who completed 30 sessions increased from 14% to 39%, and the number of participants who completed all 36 sessions also increased from 4% to 16%.[129] These findings demonstrate how efficient a quality

improvement project can be in increasing attendance and completion rates in a short period of time, emphasizing that CRPs should continually strive to evaluate and enhance program delivery.[129]

The study by Pack and colleagues[129] emphasizes the importance of frequently monitoring the performance and quality of CRPs to ensure that alterations are being made to consistently improve program delivery, participation, and the benefits that participants receive. The first step in achieving the best quality of CR begins by ensuring programs are legitimately recording performance measures or quality indicators, and from there improvement projects can be carried out.

### 1.5 Summary of Background

CVD is currently the leading cause of death worldwide, but the majority of CVD related mortality occurs from CAD, which accounted for over nine million global deaths in 2016.[1,2] Within Canada, CAD is a major cause of death, falling second only to cancer, where approximately 1 in 12 (2.4 million) Canadians over the age of 20 years lived with CAD in 2012-2013.[5] Across a national border to the United States, CAD is a predominant cause of death currently accounting for 43.8% of the lives lost to CVD.[7]

CR is a secondary prevention strategy delivered by a multidisciplinary team of health professionals, with a focus on lifestyle interventions to manage the modifiable risk factors associated with CVD and ultimately CAD.[69] Exercise-based CR has been shown to improve clinical outcomes and HRQoL for individuals with CAD.[68]

These benefits are delivered by utilizing the core components of CR to improve an individual's disease status.[17,22] Consequently, outcome assessments are necessary to ensure the efficacy of a CRP to deliver benefits to the participant.[17,22] The CCS, and the AHA in conjunction with the ACC, have formally provided quality indicators for CRPs in Canada and the United States to be evaluated, respectively.[95,97] Despite the necessity of CR, CRPs in Canada and the United States have yet to create a standard of care where all quality indicators (e.g., CR enrollment and completion) are being fulfilled to capacity (i.e., 100% quality).[127,128]

In fact, CR utilization and completion rates in both the Canada and the United States remain suboptimal.[96,103] Moreover, specific populations are less likely to participate in CR (e.g., women, older individuals) and an array of other barriers exist (e.g., transportation, financial constraints) that prevent individuals from participating in and completing CR.[107–114,128]

## References


1. WHO. Cardiovascular diseases (CVDs). World Health Organization. https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds). Published 2017. Accessed January 4, 2019.

2. WHO. The top 10 causes of death. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death. Published 2018. Accessed January 4, 2019.

3. Zipes D, Libby P, Bonow R, Mann D, Tomaselli G, Braunwald E. *Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine*. 11th ed. Philadelphia, Pennsylvania: Elsevier; 2018.

4. Thériault L, Stonebridge C, Browarski S. The Canadian heart health strategy: Risk factors and future cost implications. *Conf Board Can*. 2010:1-36.

5. Public Health Agency of Canada. *Report from the Canadian Chronic Disease Surveillance System: Heart Disease in Canada, 2018*; 2018. http://publications.gc.ca/collections/collection_2018/aspc-phac/HP35-85-1-2018-eng.pdf. Accessed January 4, 2019.

6. Public Health Ontario. Chronic disease mortality snapshot. Ontario Agency for Health Protection and Promotion. https://www.publichealthontario.ca/en/DataAndAnalytics/Snapshots/Pages/Chronic-Disease-Mortality.aspx. Published 2017. Accessed January 4, 2019.

7. Benjamin EJ, Virani SS, Callaway CW, et al. Heart disease and stroke statistics—2018 update: A report from the American Heart Association. *Circulation*. 2018;137:e67-e492. doi:10.1161/CIR.0000000000000558.

8. CDC. Stats of the state of Michigan. Centres for Disease Control and Prevention. https://www.cdc.gov/nchs/pressroom/states/michigan/michigan.htm. Published October 4, 2018. Accessed January 4, 2019.

9. Jagadeesh G, Balakumar P, Maung-U K, eds. *Pathophysiology and Pharmacotherapy of Cardiovascular Disease*. Switzerland: Springer International Publishing; 2015. doi:10.1007/978-3-319-15961-4.

10. Sandoo A, Veldhuijzen van Zanten JJCS, Metsios GS, Carroll D, Kitas GD. The endothelium and its role in regulating vascular tone. *Open Cardiovasc Med J*. 2010;4:302-312. doi:10.2174/1874192401004010302.

11. Kenney W, Wilmore J, Costil D. *Physiology of Sport and Exercise*. 5th ed. Champaign, IL: Human Kinetics; 2012.

12. Moore G, Durstine J, Painter P. *ACSM'S Exercise Management for Persons with Chronic Diseases and Disabilities*. 4th ed. Champaign, Illinois: Human Kinetics; 2016.

13. Chistiakov DA, Orekhov AN, Bobryshev YV. Effects of shear stress on endothelial cells: Go with the flow. *Acta Physiol*. 2017;219:382-408. doi:10.1111/apha.12725.

14. McLaren JE, Michael DR, Ashlin TG, Ramji DP. Cytokines, macrophage lipid metabolism and foam cells: Implications for cardiovascular disease therapy. *Prog Lipid Res*. 2011;50:331-347. doi:10.1016/j.plipres.2011.04.002.

15. Chistiakov DA, Orekhov AN, Bobryshev YV. Endothelial barrier and its abnormalities in cardiovascular disease. *Front Physiol*. 2015;6:1-11. doi:10.3389/fphys.2015.00365.

16. Ramji DP, Davies TS. Cytokines in atherosclerosis: Key players in all stages of disease and promising therapeutic targets. *Cytokine Growth Factor Rev*. 2015;26:673-685. doi:10.1016/j.cytogfr.2015.04.003.

17. AACVPR. *Guidelines for Cardiac Rehabilitation and Secondary Prevention Programs*. 5th ed. Champaign, Illinois: Human Kinetics; 2013.

18. Schoenhagen P, Ziada KM, Vince DG, Nissen SE, Tuzcu EM. Arterial remodeling and coronary artery disease: The concept of “dilated” versus “obstructive” coronary atherosclerosis. *J Am Coll Cardiol*. 2001;38:297-306. doi:10.1016/S0735-1097(01)01374-2.

19. Mori H, Finn AV, Kolodgie FD, Davis HR, Joner M, Virmani R. Atherogenesis: The development of stable and unstable plaques. In: Escaned J, Davies J, eds. *Physiological Assessment of Coronary Stenoses and the Microcirculation*. London: Springer; 2017:21-37. doi:10.1007/978-1-4471-5245-3_2.

20. Franklin B, Dixon S. *The Heart-Healthy Handbook: Written to Help Patients Help Themselves*. Monterey, California: Healthy Learning; 2017.

21. Mozaffarian D, Benjamin EJ, Go AS, et al. Executive summary: Heart disease and stroke statistics—2016 update. *Circulation*. 2016;133:447-454.

22. CACR. *Canadian Guidelines for Cardiac Rehabilitation and Cardiovascular Disease Prevention: Translating Knowledge into Action*. 3rd ed. Winnipeg, Man.: Canadian Association of Cardiac Rehabilitation; 2009.

23. Andreadis EA. *Hypertension and Cardiovascular Disease*. Switzerland: Springer Nature; 2016.

24. Nerenberg KA, Zarnke KB, Leung AA, et al. Hypertension Canada's 2018 guidelines for diagnosis, risk assessment, prevention, and treatment of hypertension in adults and children. *Can J Cardiol*. 2018;34:506-525. doi:10.1016/j.cjca.2018.02.022.

25. Whelton PK, Carey RM, Aronow WS, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults. *J Am Coll Cardiol*. 2018;71:e127-e248. doi:10.1016/j.jacc.2017.11.006.

26. Tjaden K, Pardali E, Waltenberger J. Hypercholesterolemia induces vascular cell dysfunction: Molecular basis for atherosclerosis. *Austin J Vasc Med*. 2015;2:1-9.

27. Anderson TJ, Grégoire J, Pearson GJ, et al. 2016 Canadian Cardiovascular Society guidelines for the management of dyslipidemia for the prevention of cardiovascular disease in the adult. *Can J Cardiol*. 2016;32:1263-1282. doi:10.1016/j.cjca.2016.07.510.

28. Jellinger PS, Handelsman Y, Rosenblit PD, et al. American Association of Clinical Endocrinologists and American College of Endocrinology guidelines for management of dyslipidemia and prevention of cardiovascular disease. *Endocr Pract*. 2017;23:1-87. doi:10.4158/EP171764.APPGL.

29. Stone NJ, Robinson JG, Lichtenstein AH, et al. 2013 ACC/AHA guideline on the treatment of blood cholesterol to reduce atherosclerotic cardiovascular risk in adults: A report of the American College of Cardiology/American Heart Association Task Force on practice guidelines. *Circulation*. 2014;129:S1-S45.

30. Madonna R, De Caterina R. Cellular and molecular mechanisms of vascular injury in diabetes — Part I: Pathways of vascular disease in diabetes. *Vascul Pharmacol*. 2011;54:68-74. doi:10.1016/j.vph.2011.03.005.

31. American Diabetes Association. 4. Lifestyle management: Standards of medical care in diabetes—2018. *Diabetes Care*. 2018;41:S38-S50. doi:10.2337/dc18-S004.

32. Tosti V, Bertozzi B, Fontana L. Health benefits of the Mediterranean diet: Metabolic and molecular mechanisms. *J Gerontol A Biol Sci Med Sci*. 2018;73:318-326. doi:10.1093/gerona/glx227.

33. Coelho M, Oliveira T, Fernandes R. Biochemistry of adipose tissue: An endocrine organ. *Arch Med Sci*. 2013;9:191-200. doi:10.5114/aoms.2013.33181.

34. Molica F, Morel S, Kwak B, Rohner-Jeanrenaud F, Steffens S. Adipokines at the crossroad between obesity and cardiovascular disease. *Thromb Haemost*. 2015;113:553-566. doi:10.1160/TH14-06-0513.

35. Garvey WT, Mechanick JI, Brett EM, et al. American Association of Clinical Endocrinologists and American College of Endocrinology comprehensive clinical practice guidelines for medical care of patients with obesity. *Endocr Pract*. 2016;22:1-203. doi:10.4158/EP161365.GL.

36. Messner B, Bernhard D. Smoking and cardiovascular disease: Mechanisms of endothelial dysfunction and early atherogenesis. *Arterioscler Thromb Vasc Biol*. 2014;34:509-515. doi:10.1161/ATVBAHA.113.300156.

37. Craig WY, Palomaki GE, Haddow JE. Cigarette smoking and serum lipid and lipoprotein concentrations: An analysis of published data. *BMJ*. 1989;298:784-788. doi:10.1136/bmj.298.6676.784.

38. Johnson HM, Gossett LK, Piper ME, et al. Effects of smoking and smoking cessation on endothelial function. *J Am Coll Cardiol*. 2010;55:1988-1995. doi:10.1016/j.jacc.2010.03.002.

39. Verbiest M, Brakema E, van der Kleij R, et al. National guidelines for smoking cessation in primary care: A literature review and evidence analysis. *NPJ Prim Care Respir Med*. 2017;27:2. doi:10.1038/s41533-016-0004-8.

40. Cohen BE, Edmondson D, Kronish IM. State of the art review: Depression, stress, anxiety, and cardiovascular disease. *Am J Hypertens*. 2015;28:1295-1302. doi:10.1093/ajh/hpv047.

41. Steptoe A, Kivimäki M. Stress and cardiovascular disease: An update on current knowledge. *Annu Rev Public Health*. 2013;34:337-354. doi:10.1146/annurev-publhealth-031912-114452.

42. Slavich GM, Irwin MR. From stress to inflammation and major depressive disorder: A social signal transduction theory of depression. *Psychol Bull*. 2014;140:774-815. doi:10.1037/a0035302.

43. Yang YC, Boen C, Gerken K, Li T, Schorpp K, Harris KM. Social relationships and physiological determinants of longevity across the human life span. *Proc Natl Acad Sci*. 2016;113:578-583. doi:10.1073/pnas.1511085112.

44. Uchino BN, Trettevik R, Kent de Grey RG, Cronan S, Hogan J, Baucom BRW. Social support, social integration, and inflammatory cytokines: A meta-analysis. *Health Psychol*. 2018;37:462-471. doi:10.1037/hea0000594.

45. Booth FW, Roberts CK, Laye MJ. Lack of exercise is a major cause of chronic diseases. *Compr Physiol*. 2012;2:1143-1211. doi:10.1002/cphy.c110025.

46. Adams V, Reich B, Uhlemann M, Niebauer J. Molecular effects of exercise training in patients with cardiovascular disease: Focus on skeletal muscle, endothelium, and myocardium. *Am J Physiol-Heart Circ Physiol*. 2017;313:H72-H88. doi:10.1152/ajpheart.00470.2016.

47. Palmefors H, DuttaRoy S, Rundqvist B, Börjesson M. The effect of physical activity or exercise on key biomarkers in atherosclerosis – A systematic review. *Atherosclerosis*. 2014;235:150-161. doi:10.1016/j.atherosclerosis.2014.04.026.

48. Menazza S, Murphy E. The expanding complexity of estrogen receptor signaling in the cardiovascular system. *Circ Res*. 2016;118:994-1007. doi:10.1161/CIRCRESAHA.115.305376.

49. North BJ, Sinclair DA. The intersection between aging and cardiovascular disease. *Circ Res*. 2012;110:1097-1108. doi:10.1161/CIRCRESAHA.111.246876.

50. Dhingra R, Vasan RS. Age as a cardiovascular risk factor. *Med Clin North Am*. 2012;96:87-91. doi:10.1016/j.mcna.2011.11.003.

51. Gasevic D, Ross ES, Lear SA. Ethnic differences in cardiovascular disease risk factors: A systematic review of North American evidence. *Can J Cardiol*. 2015;31:1169-1179. doi:10.1016/j.cjca.2015.06.017.

52. Hindieh W, Pilote L, Cheema A, et al. Association between family history, a genetic risk score, and severity of coronary artery disease in patients with premature acute coronary syndromes. *Arterioscler Thromb Vasc Biol*. 2016;36:1286-1292.

53. Paixao ARM, Berry JD, Neeland IJ, et al. Coronary artery calcification and family history of myocardial infarction in the Dallas Heart Study. *JACC Cardiovasc Imaging*. 2014;7:679-686. doi:10.1016/j.jcmg.2014.04.004.

54. Pandey AK, Blaha MJ, Sharma K, et al. Family history of coronary heart disease and the incidence and progression of coronary artery calcification: Multi-Ethnic Study of Atherosclerosis (MESA). *Atherosclerosis*. 2014;232:369-376. doi:10.1016/j.atherosclerosis.2013.11.042.

55. Coventry LL, Finn J, Bremner AP. Sex differences in symptom presentation in acute myocardial infarction: A systematic review and meta-analysis. *Heart Lung*. 2011;40:477-491. doi:10.1016/j.hrtlng.2011.05.001.

56. McSweeney JC, Rosenfeld AG, Abel WM, et al. Preventing and experiencing ischemic heart disease as a woman: State of the science: A scientific statement from the American Heart Association. *Circulation*. 2016;133:1302-1331. doi:10.1161/CIR.0000000000000381.

57. Thygesen K, Alpert JS, Jaffe AS, et al. Third universal definition of myocardial infarction. *J Am Coll Cardiol*. 2012;60:1581-1598. doi:10.1016/j.jacc.2012.08.001.

58. Yancy CW, Jessup M, Butler J, et al. 2013 ACCF/AHA guideline for the management of heart failure: A report of the American College of Cardiology Foundation/American Heart Association task force on practice guidelines. *Circulation*. 2013;128:e240-e327.

59. Hunt SA, Abraham WT, Chin MH, et al. 2009 focused update incorporated into the ACC/AHA 2005 guidelines for the diagnosis and management of heart failure in adults. *Circulation*. 2009;119:e391-e479. doi:10.1016/j.jacc.2008.11.013.

60. McMurray JJV, Carson PE, Komajda M, et al. Heart failure with preserved ejection fraction: Clinical characteristics of 4133 patients enrolled in the I-PRESERVE trial. *Eur J Heart Fail*. 2008;10:149-156. doi:10.1016/j.ejheart.2007.12.010.

61. Bhar-Amato J, Davies W, Agarwal S. Ventricular arrhythmia after acute myocardial infarction: 'The Perfect Storm.' *Arrhythmia Electrophysiol Rev*. 2017;6:134-139. doi:10.15420/aer.2017.24.1.

62. WHO. Global atlas on cardiovascular disease prevention and control. World Health Organization. http://www.who.int/cardiovascular_diseases/publications/atlas_cvd/en/. Published 2011. Accessed January 4, 2019.

63. Levine GN, Bates ER, Blankenship JC, et al. 2011 ACCF/AHA/SCAI guideline for percutaneous coronary Intervention: A report of the American College of Cardiology Foundation/American Heart Association Task Force on practice guidelines and the Society for Cardiovascular Angiography and Interventions. *J Am Coll Cardiol*. 2011;58:e44-e122. doi:10.1161/CIR.0b013e31823ba622.

64. Hillis LD, Anderson JL, Bittl JA, et al. 2011 ACCF/AHA guideline for coronary artery bypass graft surgery: A report of the American College of Cardiology Foundation/American Heart Association Task Force on practice guidelines. *J Am Coll Cardiol*. 2011;58:e123-e210. doi:10.1161/CIR.0b013e31823c074e.

65. Lamy A, Devereaux PJ, Prabhakaran D, et al. Five-year outcomes after off-pump or on-pump coronary-artery bypass grafting. *N Engl J Med*. 2016;375:2359-2368. doi:10.1056/NEJMoa1601564.

66. Teo KK, Cohen E, Buller C, et al. Canadian Cardiovascular Society/Canadian Association of Interventional Cardiology/Canadian Society of Cardiac Surgery position statement on revascularization—multivessel coronary artery disease. *Can J Cardiol*. 2014;30:1482-1491. doi:10.1016/j.cjca.2014.09.034.

67. Kannel WB. Contribution of the framingham study to preventive cardiology. *J Am Coll Cardiol*. 1990;15:206-211. doi:10.1016/0735-1097(90)90203-2.

68. Anderson L, Thompson DR, Oldridge N, et al. Exercise-based cardiac rehabilitation for coronary heart disease. *Cochrane Database Syst Rev*. 2016;(1). doi:10.1002/14651858.CD001800.pub3.

69. Hamm LF, Sanderson BK, Ades PA, et al. Core competencies for cardiac rehabilitation/secondary prevention professionals: 2010 Update. *J Cardiopulm Rehabil Prev*. 2011;31:2-10. doi:10.1097/HCR.0b013e318203999d.

70. Powell R, McGregor G, Ennis S, Kimani PK, Underwood M. Is exercise-based cardiac rehabilitation effective? A systematic review and meta-analysis to re-examine the evidence. *BMJ Open*. 2018;8:e019656. doi:10.1136/bmjopen-2017-019656.

71. Abell B, Zecchin R, Gallagher R. Making sense of the unfavourable systematic review of exercise-based cardiac rehabilitation in the modern era: How should we proceed? *Heart Lung Circ*. 2019;28:204-206. doi:10.1016/j.hlc.2018.07.010.

72. Oldridge N, Pakosh M, Grace SL. A systematic review of recent cardiac rehabilitation meta-analyses in patients with coronary heart disease or heart failure. *Future Cardiol*. 2019;15:227-249. doi:10.2217/fca-2018-0085.

73. Lavie CJ, Arena R, Swift DL, et al. Exercise and the cardiovascular system: Clinical science and cardiovascular outcomes. *Circ Res*. 2015;117:207-219.

74. Marzolini S, Oh PI, Brooks D. Effect of combined aerobic and resistance training versus aerobic training alone in individuals with coronary artery disease: A meta-analysis. *Eur J Prev Cardiol*. 2012;19:81-94. doi:10.1177/1741826710393197.

75. van Halewijn G, Deckers J, Tay HY, van Domburg R, Kotseva K, Wood D. Lessons from contemporary trials of cardiovascular prevention and rehabilitation: A systematic review and meta-analysis. *Int J Cardiol*. 2017;232:294-303. doi:10.1016/j.ijcard.2016.12.125.

76. Rauch B, Davos CH, Doherty P, et al. The prognostic effect of cardiac rehabilitation in the era of acute revascularisation and statin therapy: A systematic review and meta-analysis of randomized and non-randomized studies – The Cardiac Rehabilitation Outcome Study (CROS). *Eur J Prev Cardiol*. 2016;23:1914-1939. doi:10.1177/2047487316671181.

77. Anderson L, Brown JP, Clark AM, et al. Patient education in the management of coronary heart disease. *Cochrane Database Syst Rev*. 2017;(6). doi:10.1002/14651858.CD008895.pub3.

78. Richards SH, Anderson L, Jenkinson CE, et al. Psychological interventions for coronary heart disease. *Cochrane Database Syst Rev*. 2017;(4). doi:10.1002/14651858.CD002902.pub4.

79. Kavanagh T. *Take Heart: A Proven Step-by-Step Program to Improve Your Heart's Health*. Toronto, ON: Key Porter; 1998.

80. Parkinson J, Bedford D. Cardiac infarction and coronary thrombosis. *The Lancet*. 1928;211:4-11.

81. Wearn JT. Thrombosis of the coronary arteries, with infarction of the heart. *Am J Med Sci*. 1923;165:250-275. doi:10.1097/00000441-192302000-00008.

82. Leighton LS. The story of the “Cardiac Chair” and the resistance to its use in patients with acute myocardial infarction, 1950 to 1961. *Am J Cardiol*. 2017;120:1674-1680. doi:10.1016/j.amjcard.2017.07.070.

83. Irvin C, Burgess A. The abuse of bed rest in the treatment of myocardial infarction. *N Engl J Med*. 1950;243:486-489.

84. Levine S. The myth of strict bed rest in the treatment of heart disease. *Am Heart J*. 1951;42:406-413.

85. Levine S, Lown B. “Armchair” treatment of acute coronary thrombosis. *J Am Med Assoc*. 1952;148:1365-1369.

86. Beckwith JR, Kernodle DT, LeHew AE, Wood JE. The management of myocardial infarction with particular reference to the chair treatment. *Ann Intern Med*. 1954;41:1189-1195. doi:10.7326/0003-4819-41-6-1189.

87. Hellerstein H, Goldston E. Rehabilitation of patients with heart disease. *Postgrad Med*. 1954;15:265-278.

88. Gottheiner V. Long-range strenuous sports training for cardiac reconditioning and rehabilitation. *Am J Cardiol*. 1968;22:426-435.

89. Hellerstein H, Ford A. Rehabilitation of the cardiac patient. *J Am Med Assoc*. 1957;164:225-231.

90. Mampuya WM. Cardiac rehabilitation past, present and future: An overview. *Cardiovasc Diagn Ther*. 2012;2:38-49.

91. CCN. *Standards for the Provision of Cardiovascular Rehabilitation in Ontario*.; 2014. https://www.crno.ca/news/23-2014-ccn-standards-for-the-provision-of-cardiovascular-rehabilitation-in-ontario.

92. ICCPR. Welcome to the International Council of Cardiovascular Prevention and Rehabilitation (ICCPR). International Council of Cardiovascular Prevention and Rehabilitation (ICCPR). http://globalcardiacrehab.com/. Published 2013. Accessed January 4, 2019.

93. Price KJ, Gordon BA, Bird SR, Benson AC. A review of guidelines for cardiac rehabilitation exercise programmes: Is there an international consensus? *Eur J Prev Cardiol*. 2016;23:1715-1733. doi:10.1177/2047487316657669.

94. Balady GJ, Ades PA, Bittner VA, et al. Referral, enrollment, and delivery of cardiac rehabilitation/secondary prevention programs at clinical centers and beyond: A presidential advisory from the American Heart Association. *Circulation*. 2011;124:2951-2960. doi:10.1161/CIR.0b013e31823b21e2.

95. Thomas RJ, Balady G, Banka G, et al. 2018 ACC/AHA clinical performance and quality measures for cardiac rehabilitation: A report of the American College of Cardiology/American Heart Association Task Force on performance measures. *Circ Cardiovasc Qual Outcomes*. 2018;11:1-29. doi:10.1161/HCQ.0000000000000037.

96. Ades PA, Keteyian SJ, Wright JS, et al. Increasing cardiac rehabilitation participation from 20% to 70%: A road map from the million hearts cardiac rehabilitation collaborative. *Mayo Clin Proc*. 2017;92:234-242. doi:10.1016/j.mayocp.2016.10.014.

97. Grace SL, Poirier P, Norris CM, Oakes GH, Somanader DS, Suskin N. Pan-Canadian development of cardiac rehabilitation and secondary prevention quality indicators. *Can J Cardiol*. 2014;30:945-948. doi:10.1016/j.cjca.2014.04.003.

98. Grace S, Scholey P, Suskin N, et al. A prospective comparison of cardiac rehabilitation enrollment following automatic vs usual referral. *J Rehabil Med*. 2007;39:239-245. doi:10.2340/16501977-0046.

99. Grace SL, Russell KL, Reid RD, et al. Effect of cardiac rehabilitation referral strategies on utilization rates: A prospective, controlled study. *Arch Intern Med*. 2011;171:235-241. doi:10.1001/archinternmed.2010.501.

100. Gravely-Witte S, Leung YW, Nariani R, et al. Effects of cardiac rehabilitation referral strategies on referral and enrollment rates. *Nat Rev Cardiol*. 2010;7:87-96. doi:10.1038/nrcardio.2009.223.

101. Fischer JP. Automatic referral to cardiac rehabilitation. *J Cardiovasc Nurs*. 2008;23:474-479.

102. Pirruccello JP, Traynor KC, Natarajan P, et al. An electronic cardiac rehabilitation referral system increases cardiac rehabilitation referrals. *Coron Artery Dis*. 2017;28:342-345. doi:10.1097/MCA.0000000000000491.

103. Grace SL, Turk-Adawi K, Santiago de Araújo Pio C, Alter DA. Ensuring cardiac rehabilitation access for the majority of those in need: A call to action for Canada. *Can J Cardiol*. 2016;32:S358-S364. doi:10.1016/j.cjca.2016.07.001.

104. Mead H, Ramos C, Grantham SC. Drivers of racial and ethnic disparities in cardiac rehabilitation use: Patient and provider perspectives. *Med Care Res Rev*. 2016;73:251-282. doi:10.1177/1077558715606261.

105. Ghisi GLM, Polyzotis P, Oh P, Pakosh M, Grace SL. Physician factors affecting cardiac rehabilitation referral and patient enrollment: A systematic review. *Clin Cardiol*. 2013;36:323-335. doi:10.1002/clc.22126.

106. Tsui CK-Y, Shanmugasegaram S, Jamnik V, Wu G, Grace SL. Variation in patient perceptions of healthcare provider endorsement of cardiac rehabilitation. *J Cardiopulm Rehabil Prev*. 2012;32:192-197. doi:10.1097/HCR.0b013e318255a39d.

107. Ruano-Ravina A, Pena-Gil C, Abu-Assi E, et al. Participation and adherence to cardiac rehabilitation programs. A systematic review. *Int J Cardiol*. 2016;223:436-443. doi:10.1016/j.ijcard.2016.08.120.

108. Suaya JA, Stason WB, Ades PA, Normand S-LT, Shepard DS. Cardiac rehabilitation and survival in older coronary patients. *J Am Coll Cardiol*. 2009;54:25-33. doi:10.1016/j.jacc.2009.01.078.

109. Resurrección DM, Moreno-Peral P, Gómez-Herranz M, et al. Factors associated with non-participation in and dropout from cardiac rehabilitation programmes: A systematic review of prospective cohort studies. *Eur J Cardiovasc Nurs*. 2019;18:38-47. doi:10.1177/1474515118783157.

110. Beauchamp A, Worcester M, Ng A, et al. Attendance at cardiac rehabilitation is associated with lower all-cause mortality after 14 years of follow-up. *Heart*. 2013;99:620-625. doi:10.1136/heartjnl-2012-303022.

111. Supervía M, Medina-Inojosa JR, Yeung C, et al. Cardiac rehabilitation for women: A systematic review of barriers and solutions. *Mayo Clin Proc*. 2017;92:565-577. doi:10.1016/j.mayocp.2017.01.002.

112. Martin B-J, Hauer T, Arena R, et al. Cardiac rehabilitation attendance and outcomes in coronary artery disease patient. *Circulation*. 2012;126:677-687. doi:10.1161/CIRCULATIONAHA.111.066738.

113. Midence L, Mola A, Terzic CM, Thomas RJ, Grace SL. Ethnocultural diversity in cardiac rehabilitation. *J Cardiopulm Rehabil Prev*. 2014;34:437-444. doi:10.1097/HCR.0000000000000089.

114. Valencia HE, Savage PD, Ades PA. Cardiac rehabilitation participation in underserved populations: Minorities, low socioeconomic, and rural residents. *J Cardiopulm Rehabil Prev*. 2011;31:203-210. doi:10.1097/HCR.0b013e318220a7da.

115. Neubeck L, Freedman SB, Clark AM, Briffa T, Bauman A, Redfern J. Participating in cardiac rehabilitation: A systematic review and meta-synthesis of qualitative data. *Eur J Prev Cardiol*. 2012;19:494-503. doi:10.1177/1741826711409326.

116. Squires RW, Kaminsky LA, Porcari JP, Ruff JE, Savage PD, Williams MA. Progression of exercise training in early outpatient cardiac rehabilitation: An official statement from the American Association of Cardiovascular and Pulmonary Rehabilitation. *J Cardiopulm Rehabil Prev*. 2018;38:139-146. doi:info:doi/10.1097/HCR.0000000000000337.

117. Government of Canada. Canada's health care system. Government of Canada. https://www.canada.ca/en/health-canada/services/canada-health-care-system.html. Published August 22, 2016. Accessed January 4, 2019.

118. Arthur H, Swabey T, Suskin N, Ross J. The Ontario cardiac rehabilitation pilot project: Recommendations for health planning and policy. *Can J Cardiol*. 2004;20:1251-1255.

119. Medicare. Cardiac rehabilitation programs. Medicare.gov. https://www.medicare.gov/coverage/cardiac-rehabilitation-programs. Published 2019. Accessed January 4, 2019.

120. United States Government. Finding Health Insurance. Usa gov. www.usa.gov/finding-health-insurance. Published 2019. Accessed January 4, 2019.

121. ACSM. *ACSM'S Guidelines for Exercise Testing and Prescription*. 10th ed. Philadelphia, Pittsburgh: Wolters Kluwer; 2018.

122. Kachur S, Chongthammakun V, Lavie CJ, et al. Impact of cardiac rehabilitation and exercise training programs in coronary heart disease. *Prog Cardiovasc Dis*. 2017;60:103-114. doi:10.1016/j.pcad.2017.07.002.

123. Anderson L, Sharp GA, Norton RJ, et al. Home-based versus centre-based cardiac rehabilitation. *Cochrane Database Syst Rev*. 2017;(6). doi:10.1002/14651858.CD007130.pub4.

124. Gabelhouse J, Eves N, Grace SL, Reid RC, Caperchione CM. Traditional versus hybrid outpatient cardiac rehabilitation: A comparison of patient outcomes. *J Cardiopulm Rehabil Prev*. 2018;38:231-238. doi:10.1097/HCR.0000000000000253.

125. Thomas RJ, Beatty AL, Beckie TM, et al. Home-based cardiac rehabilitation. *J Am Coll Cardiol*. 2019;74:133-153. doi:10.1016/j.jacc.2019.03.008.

126. Franklin B, Bonzheim K, Gordon S, Timmis G. Safety of medically supervised outpatient cardiac rehabilitation exercise therapy: A 16-year follow up. *Chest*. 1998;114:902-906.

127. Grace SL, Parsons TL, Duhamel TA, Somanader DS, Suskin N. The quality of cardiac rehabilitation in Canada: A report of the Canadian Cardiac Rehab Registry. *Can J Cardiol*. 2014;30:1452-1455. doi:10.1016/j.cjca.2014.06.016.

128. Pack QR, Squires RW, Lopez-Jimenez F, et al. Participation rates, process monitoring, and quality improvement among cardiac rehabilitation programs in the United States: A national survey. *J Cardiopulm Rehabil Prev*. 2015;35:173-180. doi:10.1097/HCR.0000000000000108.

129. Pack QR, Johnson LL, Barr LM, et al. Improving cardiac rehabilitation attendance and completion through quality improvement activities and a motivational program. *J Cardiopulm Rehabil Prev*. 2013;33:153-159. doi:10.1097/HCR.0b013e31828db386.

# Chapter 2:

## A Comparison of Cardiac Rehabilitation Services and Outcomes in the Great Lakes Central Region (Southwestern Ontario and Southeastern Michigan)

## 2.1 Introduction

Cardiovascular disease (CVD) is currently the leading cause of death worldwide, with the majority of CVD-related deaths occurring from coronary artery disease (CAD), which accounted for over 9 million global deaths in 2016.[1,2] Within Canada, CAD is a major cause of death, second only to cancer, where approximately 1 in 12 (2.4 million) Canadians over the age of 20 years lived with CAD in 2012-2013.[3] Across a national border to the United States, CAD is a predominant cause of death currently accounting for 43.8% of the lives lost to CVD.[4]

Cardiac rehabilitation (CR) is a secondary prevention strategy delivered by a multidisciplinary team of health professionals, with a focus on lifestyle interventions to manage the modifiable risk factors associated with CVD and ultimately CAD.[5] Exercise-based CR has been shown to improve clinical outcome and health-related quality of life (HRQoL) in individuals with CAD.[6]

These benefits are delivered by utilizing the core components of CR to improve a participant's disease status.[7,8] Consequently, outcome assessments are necessary to ensure the efficacy of a cardiac rehabilitation program (CRP) to deliver benefits to the participants.[7,8] The Canadian Cardiovascular Society, and the American Heart Association in conjunction with the American College of Cardiology, have formally provided quality indicators for CRPs in Canada and the United States to be evaluated, respectively.[9,10] Despite the necessity of CR, CRPs in Canada and the United States have yet to create an ideal standard of care where all quality indicators (e.g., CR enrollment and completion) are being fulfilled to

capacity (i.e., 100% quality).[11,12] In fact, utilization and completion rates in both the Canada and the United States are suboptimal.[13,14] Moreover, specific populations are less likely to participate in CR (e.g., women, older individuals) and an array of other barriers exist (e.g., transportation, financial constraints) that prevent individuals from participating in and completing CR. [14–23]

### 2.2 Purposes and Hypotheses

CR improves clinical outcomes and HRQol in individuals with CAD. Despite this CR is underutilized around the world, including in Canada and the United States. Further, the degree of benefit in clinical subgroups and optimal duration and program content are not clear. Thus, the ultimate goal is to create a CR model (or models) that provide(s) the greatest level of care and outcomes for all participants. As a first step in this process, the purpose of this study was to compare models of care from four geographically close CR sites that span an international border through examination of program characteristics and database variables. Additionally, the participants were characterized and examined for potential predictors of program completion at one site. It is hoped that this latter work will lay a foundation for a larger-scale study spanning all four CR sites.

The following specific objectives were pursued in two phases:

**Phase 1 - Objective 1**: Describe the similarities and differences in program characteristics (e.g., referral procedures, psychosocial services offered) between and within Canadian-based (two sites) and United States-based (two sites) CRPs.

**Objective 2**: Determine common and unique database variables collected by the four CR sites.

**Phase 2 - Objective 3**: Determine factors that impacted graduation (i.e., program completion) at one of the CR sites.

**Hypothesis**: It was hypothesized that the participants would be younger individuals who were Caucasian (used interchangeably with White; African American used interchangeably with Black) men with higher socioeconomic status (i.e., higher education and employed), no comorbidities, and had coronary artery bypass grafting (CABG) as an indication for referral.[14–23] It was further hypothesized that age, sex (used interchangeably with gender), race, education, occupation status, comorbidities, and referral indication would impact program completion.[14–23]

### 2.3 Clinical Significance

CAD is the leading cause of mortality worldwide.[2] The weight of the evidence suggests that CR reduces cardiovascular disease-related deaths and hospitalizations, and improves HRQoL .[6] Despite this, CR is underutilized around the world, including in Canada and the United States. Furthermore, a standardized model of care is not implemented internationally. Therefore, by comparing the granular details of CR sites (e.g., program characteristics and database variables) within and between countries in close geographical proximity, an ideal CR model or models that increase rates of participation and program completion can be fostered. Moreover, preliminary identification of participant characteristics and associated barriers to program completion will frame the objectives for a broader study with all four sites to maximize CR participation and completion.

## 2.4 Methods

This study included four CR sites in the Great Lakes Central Region of North America: two from Southwestern Ontario (Canada) and two from Southeastern Michigan (United States). The University of Windsor (PACR Laboratory, Department of Kinesiology, Faculty of Human Kinetics, Windsor, Ontario, Canada) was deemed the central academic site. As described above in Section 2.2, this study occurred in two phases. Phase 1 compared program characteristics and database variables from all CR sites, while Phase 2 involved a single-site retrospective database analysis. This study was cleared by all institutional research ethics boards, which was captured under the master University of Windsor's Research Ethics Board (REB # 19-001/35602) clearance.

### 2.4.1 Phase 1

All four sites sent individual site program characteristics via secure email and the program characteristics from each site were compiled into one master Excel document housed at the University of Windsor. All four sites also sent individual data dictionaries (either in WORD or Excel) via secure email, which were compiled into one master Excel document housed at the University of Windsor.

### 2.4.2 Phase 2

De-identified data from thousands of historically consented participants who attended an early outpatient CRP in Michigan (Michigan Site #2) between 2012 – 2016 were extracted from the site's database and shared by secure file transfer with the University of Windsor (PACR Laboratory, Department of Kinesiology, Faculty of Human Kinetics). All non-essential identifying information was removed

by qualified CR research personnel at the site prior to transfer to the University of Windsor (PACR Laboratory, Department of Kinesiology, Faculty of Human Kinetics). Embedded in the de-identified data was no more than four HIPAA identifiers. The HIPAA identifiers included in the database were: ZIP code, sex, age, and race. To account for the inclusion of the HIPAA identifiers, a Data Sharing Agreement was created to maintain participant confidentiality and anonymity.

## 2.5 Statistical Analysis

### 2.5.1 Phase 1

The information collected from the program characteristics and data dictionaries did not require statistical analysis. These variables were compared qualitatively to determine similarities and differences. A database variable was considered to be common if at least two of the four sites (i.e., 50%) included it in their data dictionaries, and a database variable was considered to be unique if only one of the four sites included it in their data dictionary. Database variables were examined according to the Canadian Association of Cardiovascular Prevention and Rehabilitation (CACPR) and American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR) guidelines, which recommend valuable aspects to address and collect.[7,8]

### 2.5.2 Phase 2

The sample used for analyses was composed of first-time CR participants. Following data cleaning procedures (identification of duplicate and anomaly cases), descriptive statistics were conducted to characterize the population. Participant characteristics (age, sex, race, education, occupation status,

comorbidities, and referral indication) were assessed according to graduation status (graduated or not graduated) using an independent-samples t-test and chi-squared tests as appropriate to determine the factors that impacted program completion from the early outpatient CRP in Michigan. Subsequent one-way ANOVAs were conducted on occupation status and comorbidities to determine if age was statistically different between the categories of these variables.

Univariate analyses were used to determine the predictor variables included in the logistic regression. An independent-samples t-test demonstrated a significant difference in age between participants who were graduated and not graduated. Additionally, education, occupation status, and comorbidities were found to have significant associations with graduation status according to chi-squared tests and as such, age and these variables were included in the logistic regression as predictor variables. As referral indication revealed no significant association with graduation status and since it was comprised of several (10) categories that could not be collapsed into smaller categories, it was not included as a predictor variable. However, even though sex and race did not exhibit significant associations with graduation status, these variables were included in the analysis because of the potential for them to have joint predictive ability with the other variables. Subsequently, an enter-method logistic regression with graduation status (graduated or not graduated) as the outcome and participant characteristics (age, sex, race, education, occupation status, and comorbidities) as the predictor variables was conducted to further examine the factors that

impacted program completion. Data are presented as mean ± standard deviation, unless otherwise stated.

For the independent-samples t-test and one-way ANOVAs, outliers were assessed by inspection of boxplots and z-scores, and normal distribution was assessed by histograms, normal Q-Q plots, skewness, and kurtosis were appropriate. Additionally, homogeneity of variance was assessed by Levene's test for equality of variance. For the chi-squared tests, all expected cell frequencies were inspected to be greater than five for 2 by 2 contingency tables. For larger tables, all expected cell frequencies were inspected to be greater than one and no more than 20% were less than five. For the logistic regression, outliers were assessed with standardized residuals and Cook's Distance. Additionally, linearity of the log odds transformation (logit) of the dependent variable with respect to the continuous independent variable (age) (Box-Tidwell procedure), and multicollinearity (tolerance values, VIF values, and correlation coefficients) were assessed.

Statistical analyses were performed with IBM SPSS Statistics 25.0 (IBM Corp, Armonk, New York) and statistical significance was $p \leq 0.05$.

## 2.6 Results

### 2.6.1 Phase 1 – Objective 1: Program Characteristics Description

In brief, all CR sites were affiliated with a hospital and governed by their respective health care systems, and most were affiliated with a university. The Ontario sites had no program fee whereas the Michigan sites did. The Ontario sites averaged two weekly onsite sessions with an average program duration of six

months. Similarly, the Michigan sites averaged two to three weekly onsite sessions, but the average range of program duration was typically less than the Ontario sites. Please see Table 1 for details.

**Table 1: Program Overview**

| | Ontario Site #1 | Ontario Site #2 | Michigan Site #1 | Michigan Site #2 |
|---|---|---|---|---|
| **Hospital Affiliation** | Yes | Yes | Yes | Yes |
| **University Affiliation** | Yes | Yes | No | Yes |
| **Governance** | Health Care System | Health Care System | Health Care System | Health Care System |
| **Funding Source** | Ministry of Health/ Government | Ministry of Health/ Government | Commercial/ Government Insurance | Commercial/ Government Insurance |
| **Program Fee** | No; Ministry of Health /Provincial health care funding | No; Ministry of Health /Provincial health care funding | Yes; Copay/Deductible as directed by payor source | Yes; Copay/Deductible as directed by payor source |
| **Average # of Weekly Onsite Sessions** | 2 | 2 | 2-3 | 2-3 |
| **Average Program Duration** | 6 months | 6 months | 8-18 weeks | 12-18 weeks |

With respect to eligibility for referral there were many common diagnoses accepted across the sites. An Ontario site accepted diagnoses that no other sites accepted, as did the Michigan sites. Neither site in Ontario accepted “having (a) CVD risk factor(s) only (e.g., hypertension but with no CVD event)”. Please see Table 2 for details.

**Table 2: Eligibility for Referral**

| Diagnosis | Ontario Site #1 | Ontario Site #2 | Michigan Site #1 | Michigan Site #2 |
|---|---|---|---|---|
| **Myocardial Infarction** | Yes | Yes | Yes | Yes |
| **Acute Coronary Syndrome** | Not specified | Yes | Not specified | Not specified |
| **Stable Angina Pectoris** | Yes | Yes | Yes | Yes |
| **PCI/Stent** | Yes | Yes | Yes | Yes |
| **CABG** | Yes | Yes | Yes | Yes |
| **Valve Repair/Replacement** | Yes | Yes | Yes | Yes |
| **Congestive Heart Failure** | Yes | Yes | Yes | Not Specified |
| **Systolic Heart Failure** | Not specified | Not specified | Not specified | Yes |
| **LVAD** | Not specified | Not specified | Yes | Not specified |
| **Heart Transplant** | Yes | Yes | Yes | Yes |
| **Congenital Heart Disease** | Not specified | Yes | Not specified | Not specified |
| **Other Cardiac Diagnoses**[†] | Not specified | Yes | Not specified | Not specified |
| **Symptomatic PAD** | Not specified | Not specified | Yes | Not specified |

[†]Cardiac arrhythmia, implantable cardioverter-defibrillator, pacemaker, cardiomyopathy
PCI, percutaneous coronary intervention; CABG, coronary artery bypass grafting; LVAD, left ventricular assist device; PAD, peripheral arterial disease

Sites utilized a variety of automatic referral procedures, and there were nuances between and within countries. Please see Table 3 for details.

**Table 3: Referral Details**

| | Ontario Site #1 | Ontario Site #2 | Michigan Site #1 | Michigan Site #2 |
|---|---|---|---|---|
| **Procedure** | Automatic referral from acute care; paper referrals possible for outpatient settings | Automatic referral from acute care; paper referrals possible for outpatient settings | Automatic referral for inpatients at affiliated hospital or outpatients at affiliated physician office; paper referral for participants outside of affiliated health system | Automatic; no paper |
| **Require Physician Approval** | Yes | Yes | Yes | Yes |
| **Source** | Inpatient/ Outpatient | Inpatient/ Outpatient | Inpatient/ Outpatient | Inpatient/ Outpatient |
| **Rolling Enrollment** | Yes | Yes | Yes | Yes |

All sites delivered the majority of core CR components to participants, but one Michigan site did not offer pharmacotherapy management and the other Michigan site did not offer tobacco cessation. None of the sites offered participation incentives to participants. Please see Table 4 for details.

**Table 4: Core Components**

| | Ontario Site #1 | Ontario Site #2 | Michigan Site #1 | Michigan Site #2 |
|---|---|---|---|---|
| **Exercise Training** | Yes | Yes | Yes | Yes |
| **Nutritional Counselling** | Yes | Yes | Yes | Yes |
| **Psychosocial Management** | Yes | Yes | Yes | Yes |
| **Pharmacotherapy Management** | Yes | Yes | No | Yes |
| **Tobacco Cessation** | Yes | Yes | Yes | No |
| **Other Risk Factor Modification** | Yes | Yes | Yes | Yes |
| **Participation Incentives** | No | No | No | No |

All sites conducted an entry exercise test; however, one Michigan site did not conduct this test on all participants. An Ontario site estimated maximal oxygen consumption ($VO_2$) whereas the other three sites measured maximal $VO_2$. The Michigan sites used telemetry during exercise sessions with slight nuances between the two sites, while the Ontario sites did not use telemetry during exercise sessions. Please see Table 5 for details.

**Table 5: Exercise Training Details**

| | Ontario Site #1 | Ontario Site #2 | Michigan Site #1 | Michigan Site #2 |
|---|---|---|---|---|
| **Entry Exercise Test** | Yes | Yes | Yes; ~ 50% of the time when determined to be necessary by CR staff members | Yes |
| **Measured Maximal $VO_2$** | No; estimated† | Yes | Yes | Yes |
| **ECG Monitoring/ Telemetry** | No | No | Yes; first 3 sessions then discontinued; restart if clinical need | Yes; transition to no monitoring if no signs/symptoms and insurance approves |

†Measured maximal $VO_2$ is when individuals perform exercise test protocols to determine maximal $VO_2$, whereas with estimated individuals do not reach maximal $VO_2$, but instead reach submaximal $VO_2$ and maximal $VO_2$ is estimated with equations
$VO_2$, oxygen consumption; ECG, electrocardiogram

All sites collected data at intake and graduation. Three of the sites also collected data during programming but there was variation in the quantity collected. Only one site, located in Michigan, collected follow-up data. Please see Table 6 for details.

**Table 6: Data Collection Time-Points**

| | Ontario Site #1 | Ontario Site #2 | Michigan Site #1 | Michigan Site #2 |
|---|---|---|---|---|
| **Intake** | Yes | Yes | Yes | Yes |
| **During Programming** | Yes; at 3 months; laboratory results, blood pressure, and anthropometric measurements | Yes; anytime between intake and exit when warranted; all-encompassing similar to intake assessment | Yes; exercise test when deemed necessary | No |
| **Graduation** | Yes | Yes | Yes | Yes |
| **Follow-up** | No | No | No | Yes; at 1,6,12 months after graduation and every 6 months after the year mark; participant pays (not covered by insurance); all-encompassing similar to intake assessment |

All sites had a physician as the medical director. There was variation across the sites in regard to the number of staff members for each occupation. However, only one site in Ontario had a psychologist on staff. Please see Table 7 for details.

**Table 7: Staff Members**

| | Ontario Site #1 | Ontario Site #2 | Michigan Site #1 | Michigan Site #2 |
|---|---|---|---|---|
| **Medical Director** | Physician | Physician | Physician | Physician |
| **Program Director** | Kinesiologist | Occupational Therapist | Clinical Exercise Physiologist | Exercise Physiologist/Kinesiologist |
| **Exercise Physiologist/ Kinesiologist** | 6 on staff; participant interaction 2x weekly | 4 on staff; participant interaction 2x weekly | 10 on staff; participant interaction 2-3x weekly; supervise exercise; conduct 50% of education classes | 15 on staff; participant interaction 2-3x weekly |
| **Dietitian** | 1 on staff; participant interaction varies; 1x biweekly, 1x monthly, never; determined by intake assessment | 2 on staff; participant interaction varies; at intake for everyone, 2-3 visits for other participants | 1 on staff; participant interaction through conducting remaining 50% of education classes | 2 on staff; participant interaction 1x weekly |
| **Social Work/ Behaviourist/ Stress Management Specialist** | 1 on staff; participant interaction varies; biweekly, 1x monthly, never determined by intake assessment | 1.5 on staff; participant interaction varies | 0 on staff; referred to as needed by CR staff members | 1 on staff; participant interaction as needed |
| **Psychologist** | 0 on staff | 1.5 on staff; participant interaction varies; ~8 visits for those who referred by CR staff members | 0 on staff; referred to as needed by CR staff members | 0 on staff; referred to as needed by CR staff members |
| **Nurse** | 1 on staff; participant interaction at intake, 3 months, 6 months for everyone; could occur at other points if warranted (e.g., medication changes) | 3 on staff; participant interaction varies; intake and graduation; could occur for progress if warranted (e.g., medication changes) | 0 | 1; participant interaction as needed |

The number of staff members are totals without specification of full-time or part-time positions
CR, cardiac rehabilitation

Three of the sites offered home-based programming and the site that did not was located in Michigan. For the sites that offered home-based programming, there was variation across the sites regarding the details, with the largest difference existing between the Ontario sites and the Michigan site. Please see Table 8 for details.

**Table 8: Home-Based Programming**

| | **Ontario Site #1** | **Ontario Site #2** | **Michigan Site #1** | **Michigan Site #2** |
|---|---|---|---|---|
| **Available for All Participants** | Yes | Dependent on self-efficacy for exercise as determined by CR staff members | Yes | No |
| **Frequency of On-site Sessions** | Once monthly | See below | Individualized | N/A |
| **Check-ins** | No; only if participant calls | May receive phone, email, or check-in visits by CR staff members | Individualized | N/A |
| **Exercise Monitoring** | Self-directed | Self-directed | Heart rate monitor; supervised by clinician during exercise training | N/A |
| **Means of Communication with CR Staff Members** | Phone and email | Phone, email, and automated text message (piloted) | Live two-way audio and video conference | N/A |
| **Program Fee** | No | No | Yes; same as on-site, but coverage limited to 2 insurance providers | N/A |
| **Core Component(s)** | Exercise training | Exercise training | Exercise training | N/A |
| **Deliverance of Other Core Components** | Participant attends on-site CR sessions | Participant attends on-site CR sessions; phone follow-ups | Online slideshow presentations/videos | N/A |

CR, cardiac rehabilitation

### 2.6.2 Phase 1 – Objective 2: Common and Unique Database Variables

**Common Variables Collected at Intake**

**Referral and General Intake**

There were no referral and general intake variables that were collected across all four sites, however, the sites in Ontario collected the point of referral (e.g., inpatient unit, emergency room, physician office) and date of the referral.

**Medical History**

All sites collected the event or indication for referral to early outpatient CR, the diagnoses of hypertension and diabetes, and prescribed medications. Three sites (two Ontario sites and a Michigan site) collected diagnoses of hyperlipidemia, pulmonary or respiratory diseases (including sleep apnea), cerebrovascular diseases, and bone and joint or musculoskeletal impairments or diseases. Two sites (one Ontario and one Michigan) collected CVD information beyond that collected to determine indication for referral to CR. The sites in Ontario collected depression as an event or indication (i.e., diagnoses) for referral, primary CVD risk factors, additional risk factors, medication relevant diagnoses, sensory impairments, neurological diseases, and diagnosis of erectile dysfunction.

***Physical Activity or Exercise Patterns***

There were no variables that were collected across all four sites. Three sites (two Ontario sites and a Michigan site) collected musculoskeletal limitations to exercise. The Ontario sites also collected other non-cardiac limitations to exercise (e.g., neurological, sensory). The sites in Michigan collected exercise frequency.

### ***Alcohol Consumption***

There were no variables that were collected across all four sites. Three sites (two Ontario sites and a Michigan site) collected the current status of the participant drinking alcohol, the amount, and various questions related to the excessive use of alcohol.

### ***Tobacco Use***

All sites collected the current status of the participant smoking tobacco. Three sites (two Ontario sites and a Michigan site) collected the amount smoked per day and the smoking tobacco quit date, if applicable. The sites in Ontario collected the frequency of smoking tobacco and the number of years smoking tobacco.

### **Demographic Information**

All sites collected a variation of demographic variables at intake. More specifically, all sites collected address, date of birth or age, sex or gender, and race or ethnic group. Three sites (two Ontario sites and a Michigan site) collected marital status, living situation (e.g., alone, with spouse, with children), education, occupation, and current occupation status (e.g., active, unemployed, retired). The sites in Ontario also collected desired occupation status, spoken language, and type of residence (e.g., home, apartment, acute care hospital).

### **Travel Time**

There were no variables that were collected across all four sites, however the sites in Ontario collected the travel time for participants to attend CR.

**Physical Evaluation**

All sites collected blood pressure, weight, height, and a variation of dysrhythmia history. Three sites (two Ontario sites and a Michigan site) collected ejection fraction and laboratory results including a lipid profile, and glucose and glycosylated hemoglobin (HbA1c) measurements. The sites in Ontario collected resting ankle blood pressure, resting heart rate, other blood components, the Canadian Cardiovascular Society angina grade, and the New York Heart Association heart failure class.

**Exercise Test**

All sites collected the exercise test protocol used, the exercise test duration, peak blood pressure (systolic and diastolic), heart rate during the exercise test, and measured functional capacity by collecting maximal $VO_2$ or peak oxygen uptake (ml/kg/min) (estimated or measured). Additionally, all sites collected some variation of signs and symptoms that occurred during the exercise test, including electrocardiogram (ECG) changes with a focus on ischemia/ST changes and evidence of angina. Three sites (two Ontario sites and a Michigan site) collected rating of perceived exertion (utilizing a variation of the Borg Scale) during the exercise test and the reason that the exercise test was terminated. The sites in Ontario collected the exercise test location (on-site, off-site, elsewhere), resting blood pressure (systolic and diastolic) and heart rate before the exercise test, and lung function (e.g., normal, mild, obstructive disease).

It should be noted that some of the variables collected with exercise tests, which can occur at different time-points and not for every participant, could be

relevant to the *Medical History* and *Physical Evaluation* as well. As such, the variables have been included in these headings. Nonetheless, consideration needs to be made regarding the fact that if an exercise test is not conducted, this information may not be collected or may be collected in a format not captured by the current data dictionary.

**Questionnaires**

***Overall Health Related Questionnaires***

There were no common questionnaires collected.

***Psychological Health Related Questionnaires***

There were no psychological health related questionnaires that were collected across all four sites. The sites in Ontario collected the Hospital Anxiety and Depression Scale (HADS).

***Physical Health Related Questionnaires***

There were no common questionnaires collected.

***Nutrition Related Questionnaires***

There were no common questionnaires collected.

**Staff Members**

There were no variables that were collected across all four sites, but three sites (two Ontario sites and a Michigan site) collected the case manager. The sites in Ontario collected if a nurse practitioner was required and the type of care (e.g., regular, heart failure, chronic obstructive pulmonary disease [COPD]).

## Unique Variables Collected at Intake

For a summary of the unique variables collected at intake please see Table 9 below.

**Table 9: Unique Variables Collected at Intake**

| | Ontario Site #1 | Ontario Site #2 | Michigan Site #1 | Michigan Site #2 |
|---|---|---|---|---|
| **Referral and General Intake** | | | | |
| - First early outpatient CR visit that is billable | | | ✔ | |
| - Previous CR participation | | | | ✔ |
| **Medical History** | | | | |
| - Background events impairing cardiovascular health | | ✔ | | |
| - Allergies | | ✔ | | |
| - Signs and symptoms of cardiac conditions | | | | ✔ |
| - General fatigue | | | | ✔ |
| - Cancer | | | | ✔ |
| - Gastrointestinal | | | | ✔ |
| - Genitourinary | | | | ✔ |
| - Neuropsychiatric (e.g., depression, anxiety) | | | | ✔ |
| - Hematology | | | | ✔ |
| - Pregnancy history | | | | ✔ |
| - Gynecological history | | | | ✔ |
| - Family history | | | | ✔ |
| - Body weight history and eating habits† | | | | ✔ |
| ***Physical Activity or Exercise Patterns*** | | | | |
| - Type of exercise performed (cardio or strength training) | | | | ✔ |
| - Amount for each type of exercise | | | | ✔ |
| - Accessibility to exercise equipment at home | | | | ✔ |
| - Membership to a gym | | | | ✔ |
| ***Alcohol Consumption*** | | | | |
| - Motivation to quit drinking alcohol (0-10 scale) | | | | ✔ |
| ***Tobacco Use*** | | | | |
| - Number of quitting attempts | | ✔ | | |
| - Acceptance of inpatient or outpatient smoking cessation services | | ✔ | | |
| - Type of tobacco smoked (cigarettes, cigars, pipe, smokeless tobacco) | | | | ✔ |
| - Amount each type of tobacco is used | | | | ✔ |
| - Quit date for each type of tobacco | | | | ✔ |
| - Motivation to quit smoking (0-10 scale) | | | | ✔ |

| | | | | |
|---|---|---|---|---|
| - Status of a participant living with someone who smokes | | | | ✔ |
| **Demographic Information** | | | | |
| - Insurance information | | | ✔ | |
| - Religion | | | | ✔ |
| - Rating of one's marriage (e.g., excellent, poor) | | | | ✔ |
| - Number of children | | | | ✔ |
| - Social support (i.e., the main source and the rating for the amount received) | | | | ✔ |
| **Physical Evaluation** | | | | |
| - Framingham risk score | | ✔ | | |
| - Fall related questions | ✔ | | | |
| - Body composition | | | | ✔ |
| - Criteria for metabolic syndrome | | | | ✔ |
| - Electrocardiogram evidence of left ventricular hypertrophy | | | | ✔ |
| - Myocardial infarction or cardiac surgery complicated by cardiogenic shock | | | | ✔ |
| - Coronary angiography and obstruction details | | | | ✔ |
| - Lower and upper heart range | | | ✔ | |
| - Indication for use of rating of perceived exertion only | | | ✔ | |
| **Exercise Test** | | | | |
| - Reason for the exercise test (i.e., for early outpatient cardiac rehabilitation or not) | | ✔ | | |
| - Supine blood pressure (systolic and diastolic) and heart rate | | ✔ | | |
| - Standing blood pressure (systolic and diastolic) and heart rate | | ✔ | | |
| - Test type in regard to estimated or measured functional capacity | | | | ✔ |
| - 6-minute hall walk results | | | | ✔ |
| - Specific signs and symptoms included arrhythmia information and systolic blood pressure response (e.g., hypo, blunted) | | | | ✔ |
| **Questionnaires** | | | | |
| ***Overall Health Related Questionnaires*** | | | | |
| - Short Form (12) Health Survey (SF-12) | | ✔ | | |
| - Short Form (36) Health Survey Version 2.0 (SF-36 V2) | | | | ✔ |
| - Dartmouth COOP Health Survey | | | ✔ | |
| ***Psychological Health Related Questionnaires*** | | | | |
| - Patient Health Questionnaire (PHQ-9) | | | ✔ | |
| - Brief Symptom Inventory (BSI-53) | | | | ✔ |
| ***Physical Health Related Questionnaires*** | | | | |
| - Duke Activity Status Index (DASI) | | ✔ | | |
| - Human Activity Profile (HAP) | | ✔ | | |
| ***Nutrition Related Questionnaires*** | | | | |
| - Rate Your Plate | | | ✔ | |

| | | | | |
|---|---|---|---|---|
| - Customized Food Frequency Survey/Assessment | | | | ✔ |

† Database variables included: a healthy weight the participant considered for themselves, previous or current weight-loss programs, previous dietician counselling, motivation, confidence and obstacles to implementing improvements in diet

## Common Variables Collected During Programming

### Attendance

There were no variables that were collected across all four sites. The sites in Ontario collected attendance rates for specific core components including: attendance for cardiac education (independent and group), diabetes education, dietary counselling (independent), dietary education (group), exercise counselling (independent), exercise education (group), medication counselling (independent and group), psychosocial education (group), stress management (group), supervised exercise, home-based exercise, smoking cessation, psychology services, social work services, women's support group, vocational assessment and counselling, and pharmacotherapeutic sessions. The sites in Michigan collected the total number of early outpatient CR sessions attended.

## Unique Variables Collected During Programming

For a summary of the unique variables collected during programming please see Table 10 below.

**Table 10: Unique Variables Collected During Programming**

| | Ontario Site #1 | Ontario Site #2 | Michigan Site #1 | Michigan Site #2 |
|---|---|---|---|---|
| **Attendance** | | | | |
| - Exercise training days per week | ✔ | | | |
| - Total electrocardiogram monitored sessions | | | ✔ | |
| - Number of sessions approved | | | | ✔ |
| - Number of sessions prescribed | | | | ✔ |
| - Number of sessions per week | | | | ✔ |

## Common Variables Collected at Graduation

### Medical History

There were no variables that were collected across all four sites. Three sites (two Michigan sites and an Ontario site) collected prescribed medications. Three different sites (two Ontario sites and a Michigan site) collected the presence of hypertension. The Ontario sites collected if participants were sedentary, had high blood cholesterol, or psychological concerns at graduation, and if the participants were going to attend pulmonary rehabilitation.

#### *Physical Activity or Exercise Patterns*

There were no variables that were collected across all four sites. The sites in Michigan collected exercise frequency.

#### *Alcohol Consumption*

There were no variables that were collected across all four sites. An Ontario site and a Michigan site collected the current status of the participant drinking alcohol, the amount, and various questions related to the excessive use of alcohol.

#### *Tobacco History*

There were no variables that were collected across all four sites. Three sites (two Michigan sites and an Ontario site) collected the current status of the participant smoking tobacco. An Ontario and a Michigan site collected the amount smoked per day.

### Demographic Information

There were no variables that were collected across all four sites. The Ontario sites collected occupation status (e.g., active, unemployed, retired).

## Physical Evaluation

All sites collected resting blood pressure. Three sites (two Michigan sites and an Ontario site) collected weight. An Ontario and Michigan site collected laboratory results including a lipid profile, glucose, and glycosylated hemoglobin (HbA1c) measurements, and resting heart rate.

## Exercise Test

All sites conducted an exercise test at graduation and collected relative variables. Please refer to *Exercise Test* under *Variables Collected at Intake* for more detail.

It should be noted that some of the variables collected with exercise tests, which can occur at different time-points and not for every participant, could be relevant the *Medical History* and *Physical Evaluation* as well. As such, the variables have been included in these headings. Nonetheless, consideration needs to be made regarding the fact that if an exercise test is not conducted, this information may not be collected or may be collected in a format not captured by the current data dictionary.

## Questionnaires

### *Overall Health Related Questionnaires*

There were no common questionnaires collected.

### *Psychological Health Related Questionnaires*

There were no common questionnaires collected.

### *Physical Health Related Questionnaires*

There were no common questionnaires collected.

### ***Nutrition Related Questionnaires***

There were no common questionnaires collected.

### ***Program Evaluation Questionnaire***

There were no common questionnaires collected.

## Reason for Graduation

There were no variables that were collected across all four sites. Three sites (two Ontario sites and a Michigan site) collected the reason a participant graduated or ceased to attend CR (e.g., completed program, insurance, return to work).

## Unique Variables Collected at Graduation

For a summary of the unique variables collected at graduation (i.e., program completion) please see Table 11 below.

**Table 11: Unique Variables Collected at Graduation**

| | Ontario Site #1 | Ontario Site #2 | Michigan Site #1 | Michigan Site #2 |
|---|---|---|---|---|
| **Medical History** | | | | |
| - Lower limb claudication | | ✔ | | |
| - Pulmonary or respiratory diseases | | ✔ | | |
| - Cerebrovascular diseases | | ✔ | | |
| - Bone and joint or musculoskeletal impairments or diseases | | ✔ | | |
| - Sensory impairments | | ✔ | | |
| - Neurological diseases | | ✔ | | |
| - Erectile dysfunction | | ✔ | | |
| - Allergies | | ✔ | | |
| - Signs and symptoms of cardiac conditions | | | | ✔ |
| - Cardiac events or tests since the participant's previous evaluation | | | | ✔ |
| - Gynecological history | | | | ✔ |
| - Diabetes | | | ✔ | |
| ***Physical Activity or Exercise Patterns*** | | | | |
| - If strength training was being performed | | | | ✔ |
| - Accessibility to exercise equipment at home | | | | ✔ |
| - Membership to a gym | | | | ✔ |
| - Participant's exercise plan following graduation | | | ✔ | |
| ***Alcohol Consumption*** | | | | |
| - Motivation to quit drinking alcohol (0-10 scale) | | | | ✔ |
| ***Tobacco Use*** | | | | |

| | | | | |
|---|---|---|---|---|
| - Frequency of smoking tobacco | | ✔ | | |
| - Number of years smoking tobacco | | ✔ | | |
| - Number of quitting attempts | | ✔ | | |
| - Smoking tobacco quit date | | ✔ | | |
| - Type of tobacco smoked (cigarettes, cigars, pipe, smokeless tobacco) | | | | ✔ |
| - Amount each type of tobacco is used | | | | ✔ |
| - Motivation to quit smoking (0-10 scale) | | | | ✔ |
| - Obstacles to quitting | | | | ✔ |
| - Tobacco products quit in the last 6 months | | | | ✔ |
| - Status of a participant living with someone who smokes | | | | ✔ |
| **Physical Evaluation** | | | | |
| - Resting ankle blood pressure | | ✔ | | |
| - Resting heart rate | | ✔ | | |
| - Blood components beyond lipid profile, glucose, and glycosylated hemoglobin (HbA1c) | | ✔ | | |
| - Canadian Cardiovascular Society angina grade | | ✔ | | |
| - New York Heart Association heart failure class | | ✔ | | |
| - Ejection fraction | | ✔ | | |
| - Dysrhythmia history | | ✔ | | |
| - Body composition | | | ✔ | |
| **Questionnaires** | | | | |
| ***Overall Health Related Questionnaires*** | | | | |
| - Short Form (12) Health Survey (SF-12) | | ✔ | | |
| - Short Form (36) Health Survey Version 2.0 (SF-36 V2) | | | | ✔ |
| - Dartmouth COOP Health Survey | | | ✔ | |
| ***Psychological Health Related Questionnaires*** | | | | |
| - Hospital Anxiety and Depression Scale (HADS) | | ✔ | | |
| - Patient Health Questionnaire (PHQ-9) | | | ✔ | |
| - Brief Symptom Inventory (BSI-53) | | | | ✔ |
| ***Physical Health Related Questionnaires*** | | | | |
| - Duke Activity Status Index (DASI) | | ✔ | | |
| - Human Activity Profile (HAP) | | ✔ | | |
| ***Nutrition Related Questionnaires*** | | | | |
| - Rate Your Plate | | | ✔ | |
| - Customized Food Frequency Survey/Assessment | | | | ✔ |
| ***Program Evaluation Questionnaire*** | | | | |
| - Customized Patient Satisfaction Survey | | | ✔ | |
| **Behaviour Modification/Program Compliance Problems** | | | | |
| - Taking medications | | | | ✔ |
| - Getting regular exercise | | | | ✔ |
| - Quitting smoking | | | | ✔ |
| - Eating correctly | | | | ✔ |
| - Controlling body weight | | | | ✔ |
| - Drinking alcohol in moderation or not at all | | | | ✔ |
| - Coping with stress | | | | ✔ |

### 2.6.3 Phase 2 – Objective 3: Michigan Site Data Analysis

Data cleaning identified no duplicate cases, but one anomaly case was removed from the sample producing the final sample size of 1265 CR participants.

**Characterization of Population**

Participants were predominately Caucasian (*n* = 1044*),* men (*n* = 896), university educated (*n* = 633), and not actively employed (*n* = 634). More than one half of the population had two or more comorbidities (*n* = 749). The three most common referral indications were percutaneous coronary intervention (PCI)/Stent (*n* = 312*)*, myocardial infarction (MI) (*n* = 272*)*, and valve replacement/repair (*n* = 207*)*. Please see Table 12 for details.

**Table 12: Participant Characteristics**

| | **Total Sample (N = 1265)** |
|---|---|
| **Age (years; mean ± SD)** | 62.51 ± 11.81 |
| **Sex (*n*; % of total sample)** | |
| Women | 369 (29.2%) |
| Men | 896 (70.8%) |
| **Race (*n*; % of total sample)** | |
| Caucasian | 1044 (82.5%) |
| African American | 86 (6.8%) |
| Other | 135 (10.7%) |
| **Education† (*n*; % of total sample)** | |
| University | 633 (50.1%) |
| College/Post-Secondary | 378 (29.9%) |
| High School or Less | 187 (14.8%) |
| Unknown | 65 (5.1%) |
| **Occupation Status (*n*; % of total sample)** | |
| Active | 574 (45.4%) |
| Retired | 510 (40.3%) |
| Unemployed | 40 (3.2%) |
| Medically Disabled | 84 (6.6%) |
| Unknown | 57 (4.5%) |
| **Comorbidities‡ (*n*; % of total sample)** | |

| | |
|---|---|
| No Comorbidity | 221 (17.6%) |
| 1 Comorbidity | 287 (22.8%) |
| 2 Comorbidities | 350 (27.8%) |
| >2 Comorbidities | 399 (31.7%) |
| **Referral Indication (*n*; % of total sample)** | |
| PCI/Stent | 312 (24.7%) |
| MI | 272 (21.5%) |
| Valve Replacement/Repair | 207 (16.4%) |
| CABG | 185 (14.6%) |
| MI/PCI | 157 (12.4%) |
| Heart Failure | 50 (4.0%) |
| CABG/Valve Replacement/Repair | 28 (2.2%) |
| Stable Angina | 26 (2.1%) |
| Heart Transplant | 5 (0.4%) |
| Other | 23 (1.8%) |

†Education had 2 (0.2%) system missing cases
‡Comorbidities had 8 (0.6%) system missing cases
SD, standard deviation; PCI, percutaneous coronary intervention; MI, myocardial infarction; CABG, coronary artery bypass grafting

## Participant Factors and Program Completion

Program completion or graduation for a participant was classified as the participant attending at least 75% of the CR sessions that were prescribed to the participant. The number of prescribed sessions varied according to the number of sessions approved by insurance, which is typically 36 sessions. Most participants in the current sample (64.4%) were prescribed 36 sessions. Graduation status (graduated or not graduated) was not recorded for two participants from the original sample (N = 1265), consequently the final sample size was 1263 participants. There were 321 (25.4%) non-graduates and 942 (74.6%) graduates. Participant factors and graduation status are reported below and summarized in Table 13.

**Comparison of Graduation Status and Age**

An independent-samples t-test revealed a significant difference in age between non-graduates and graduates. Non-graduates (60.47 years ± 12.44) were significantly younger than graduates (63.21 years ± 11.52) [difference = -2.74 years (95% confidence interval [CI], -4.23 to -1.24); $t(1261) = -3.599$, $p < 0.0005$].

**Comparison of Graduation Status and Sex**

A chi-squared test revealed no significant association between graduation status and sex (men or women), $\chi^2(1) = 0.004$, $p = 1.00$.

**Comparison of Graduation Status and Race**

A chi-squared test revealed no significant association between graduation status and race (Caucasian, African American, and other [Asian, Hispanic, Middle Eastern, Native American, South East Asian, other, unknown]), $\chi^2(2) = 0.087$, $p = 0.958$.

**Comparison of Graduation Status and Education**

A chi-squared test revealed a significant association between graduation status and education (university [bachelor's degree, some post graduate, master's degree, PhD, and medical doctor], college/post-secondary [some college, trade school, and associate's degree], high school or less [some high school and high school/GED], and unknown), $\chi^2(3) = 35.887$, $p < 0.0005$. The proportion of graduates (54.9%) with university education was significantly more than those that did not graduate (36.3%). The proportion of graduates with college/post-secondary education (27.4%) or high school or less education (12.6%) was significantly less than the proportion that did not graduate (36.9% and 21.3%, respectively).

**Comparison of Graduation Status and Occupation Status**

A chi-squared test revealed a significant association between graduation status and occupation status (active, retired, unemployed, medically disabled, and unknown), $\chi^2(4) = 22.786$, $p < 0.0005$. The proportion of graduates (42.6%) that were retired was significantly more than the proportion that did not graduate (33.6%). The proportion of graduates that were medically disabled (4.9%) was significantly less than the proportion that did not graduate (11.5%).

**Comparison of Graduation Status and Comorbidities**

A chi-squared test revealed a significant association between graduation status and number of comorbidities (none, one, two, and greater than two), $\chi^2(3) = 8.607$, $p = 0.035$. The comorbidities included any type of cancer, hypertension, high blood cholesterol, bronchitis (as a measure of COPD), emphysema (as a measure of COPD), stroke, diabetes, kidney disease, and depression. The proportion of graduates that had more than two comorbidities (29.7%) was significantly less than the proportion that did not graduate (38.1%).

**Comparison of Graduation Status and Referral Indication**

A chi-squared test revealed no significant association between graduation status and referral indication (MI, PCI/stent, MI/PCI, CABG, valve replacement/repair, CABG/valve replacement/repair, heart transplant, stable angina, heart failure, other), $\chi^2(9) = 6.865$, $p = 0.651$.

**Table 13: Participant Factors and Graduation Status**

| | **Graduation Status (N = 1263)** | | |
|---|---|---|---|
| | **Graduated (*n* = 942)** | **Not Graduated (*n* = 321)** | ***P* Value** |
| **Age (years; mean ± SD)** | 63.21 ± 11.52 | 60.47 ± 12.44 | < 0.0005* |

| | | | |
|---|---|---|---|
| **Sex (*n*; % within graduation status)** | | | 1.00 |
| Women | 274 (29.1%) | 94 (29.3%) | |
| Men | 668 (70.9%) | 227 (70.7%) | |
| **Race (*n*; % within graduation status)** | | | 0.958 |
| Caucasian | 778 (82.6%) | 264 (82.2%) | |
| African American | 63 (6.7%) | 23 (7.2%) | |
| Other | 101 (10.7%) | 34 (10.6%) | |
| **Education‡ (*n*; % within graduation status)** | | | < 0.0005* |
| University† | 517 (54.9%) | 116 (36.3%) | |
| College/Post-Secondary† | 258 (27.4%) | 118 (36.9%) | |
| High School or Less† | 119 (12.6%) | 68 (21.3%) | |
| Unknown | 47 (5.0%) | 18 (5.6%) | |
| **Occupation Status (*n*; % within graduation status)** | | | < 0.0005* |
| Active | 428 (45.4%) | 146 (45.5%) | |
| Retired† | 401 (42.6%) | 108 (33.6%) | |
| Unemployed | 29 (3.1%) | 11 (3.4%) | |
| Medically Disabled† | 46 (4.9%) | 37 (11.5%) | |
| Unknown | 38 (4.0%) | 19 (5.9%) | |
| **Comorbidities§ (*n*; % within graduation status)** | | | 0.035* |
| No Comorbidity | 172 (18.4%) | 49 (15.4%) | |
| 1 Comorbidity | 225 (24.0%) | 62 (19.5%) | |
| 2 Comorbidities | 262 (28.0%) | 86 (27.0%) | |
| >2 Comorbidities† | 278 (29.7%) | 121 (38.1%) | |
| **Referral Indication (*n*; % within graduation status)** | | | 0.651 |
| PCI/Stent | 222 (23.6%) | 89 (27.7%) | |
| MI | 201 (21.3%) | 70 (21.8%) | |
| Valve Replacement/Repair | 157 (16.7%) | 50 (15.6%) | |
| CABG | 147 (15.6%) | 38 (11.8%) | |
| MI/PCI | 122 (13.0%) | 35 (10.9%) | |
| Heart Failure | 36 (3.8%) | 14 (4.4%) | |
| CABG/Valve Replacement/Repair | 20 (2.1%) | 8 (2.5%) | |
| Stable Angina | 18 (1.9%) | 8 (2.5%) | |
| Heart Transplant | 4 (0.4%) | 1 (0.3%) | |
| Other | 15 (1.6%) | 8 (2.5%) | |

*$p \leq 0.05$
†Significantly different column proportions
‡Education had 2 system missing cases; therefore, n = 1261 for relative analysis
§Comorbidities had 8 system missing cases; therefore, n = 1255 for relative analysis
SD, standard deviation; PCI, percutaneous coronary intervention; MI, myocardial infarction; CABG, coronary artery bypass grafting

**Comparison of Age and Occupation Status**

Since age was significantly different between graduates and non-graduates, and occupation status had a significant association with graduation status (discussed above), a one-way ANOVA was conducted to determine if age differed based on occupation status. There were no identified system missing cases (N = 1265). Homogeneity of variances was violated as assessed by Levene's test for equality of variance ($p = 0.002$). Therefore, a Welch ANOVA was conducted and revealed that age was significantly different between different occupation status, Welch's $F(4, 153.978) = 195.932$, $p < 0.0005$. Participants were categorized into five groups: active (*n* = 574; 56.65 years ± 10.18), retired (*n* = 510; 71.01 years ± 8.37), unemployed (*n* = 40; 56.55 years ± 7.75), medically disabled (*n* = 84; 53.77 years ± 9.36), and unknown (*n* = 57; 62.46 years ± 11.35). Games-Howell post hoc analysis revealed that the differences in age between retired participants and that who were unknown (-8.56 years, 95% CI -12.903 to -4.208), active (-14.36 years, 95% CI -15.902 to -12.821), unemployed (-14.46 years, 95% CI -18.093 to -10.831), or medically disabled (-17.24 years, 95% CI -20.253 to -14.223) were all statistically significant ($p < 0.0005$), with retired individuals being the oldest participants.

**Comparison of Age and Prevalence of Comorbidities**

Since age was significantly different between graduates and non-graduates, and the prevalence of comorbidities had a significant association with graduation status (discussed above), a one-way ANOVA was conducted to determine if age differed based on comorbidity prevalence. There were eight

identified system missing cases for comorbidities (N = 1257). A one-way ANOVA revealed that age was statistically significantly different between the groups with different frequencies of comorbidities, $F(3,1253) = 8.657$, $p < 0.0005$. Participants were categorized into four groups: greater than two comorbidities (*n* = 399; 64.28 years ± 10.76), two comorbidities (*n* = 350; 63 years ± 11.65), one comorbidity (*n* = 287; 61.83 years ± 12.52) and no comorbidity (*n* = 221; 59.43 years ± 12.32). Tukey post hoc analysis revealed that the increase in age between greater than two comorbidities and no comorbidity groups (4.85 years, 95% CI 2.321 to 7.371) was statistically significant ($p < 0.0005$), indicating that participants with greater than two comorbidities were older. Similarly, the increase in age between greater than two comorbidities and one comorbidity groups (2.45 years, 95% CI 0.116 to 4.777) was statistically significant ($p = 0.035$), indicating that participants with greater than two comorbidities were older. Additionally, the increase between two comorbidities and no comorbidity groups (3.57 years, 95% CI 0.983 to 6.157) was statistically significant ($p = 0.002$), indicating that participants with two comorbidities were older.

**Logistic Regression Model for Graduation Status**

There were 12 identified system missing cases among all included variables; therefore, N = 1253. A logistic regression was performed to determine the likelihood that participants graduated or did not graduate from the program with age, sex, race, education, occupation status, and comorbidities as predictors in the model. A test of the final model, including all six predictors, compared to the constant only model was statistically significant $\chi^2(14) = 63.022$, $p < 0.0005$,

Nagelkerke $R^2$ = 0.072. The model correctly classified 75.1% of cases. Age was significantly associated with graduation status, where a one unit (one year) increase in age was associated with a 1.6% increase in the likelihood of graduating (odds ratio [OR] 1.016, 95% CI 1.002 to 1.030, p = 0.027). Education was significantly associated with graduation status, were compared to university education, high school or less education (OR 0.435, 95% CI 0.297 to 0.637, p < 0.0005) and college/post-secondary education (OR 0.518, 95% CI 0.380 to 0.707, p < 0.0005) decreased the likelihood of graduating by 56.5% and 48.2%, respectively. The predictor comorbidities were trending towards significance (p = 0.067). The results for the logistic regression are presented in Table 14.

**Table 14: Predictors of Program Completion**

| **Predictor** | **Odds Ratio (95% CI)** | ***P* Value** |
|---|---|---|
| **Age (years)** | 1.016 (1.002-1.030) | 0.027* |
| **Sex (ref: men)** | 1.136 (0.847-1.525) | 0.395 |
| **Race (ref: Caucasian)** | | 0.579 |
| African American | 1.319 (0.779-2.234) | 0.303 |
| Other | 0.982 (0.640-1.508) | 0.935 |
| **Education (ref: university)** | | < 0.0005* |
| High School or Less | 0.435 (0.297-0.637) | < 0.0005* |
| College/Post-Secondary | 0.518 (0.380-0.707) | < 0.0005* |
| Unknown | 0.640 (0.335-1.222) | 0.176 |
| **Occupation Status (ref: active)** | | 0.106 |
| Retired | 1.181 (0.823-1.693) | 0.366 |
| Unemployed | 1.211 (0.575-2.553) | 0.614 |
| Medically Disabled | 0.583 (0.351-0.969) | 0.037 |
| Unknown | 0.739 (0.384-1.419) | 0.363 |
| **Comorbidities (ref: >2 comorbidities)** | | 0.067 |
| No Comorbidity | 1.502 (1.002-2.253) | 0.049 |
| 1 Comorbidity | 1.553 (1.076-2.241) | 0.019 |
| 2 Comorbidity | 1.332 (0.951-1.866) | 0.095 |

*p ≤ 0.05
CI, confidence interval; ref, reference group

## 2.7 Discussion

CAD is the leading cause of mortality worldwide.[2] CR is a secondary prevention program known to improve clinical outcomes and HRQoL in patients with CAD.[6] Despite this, CR is underutilized around the world, and a CR model or models that is/are most efficient for all cohorts of participants in varying locations has yet to be established.[13,14] The global CR "process" from referral to program completion is fairly similar, yet the "granular" details are less uniform: program characteristics, database dictionaries (e.g., what information is collected from participants and when), and participant characteristics vary, additionally different participant-level and system-level barriers exist. Consequently, not all standard-of-care quality indicators are being met. To provide the greatest level of care, achieve the best possible outcome, and lower participant- and system-level barriers, it is essential to create an ideal CR model (or models) that encourage attendance and completion while meeting all standard of care quality indicators. This study took an important first step toward creating such a model (or models). Key findings emerging from this study are summarized in Table 15. These important findings are discussed in more detail below.

## Table 15: Key Findings

| Objective 1: Program Characteristics Description |
|---|
| • All sites may want to consider “pre-habilitation” programs for individuals who have not yet had a CVD event, but have CVD risk factors |
| • All sites may want to implement cost-effective participation incentives |
| • Michigan sites may want to consider adopting the “use as needed” format for telemetry; similar to Ontario sites |
| • All sites may want to consider collecting more participant data during programming |
| **Objective 2: Common and Unique Database Variables** |
| • All sites may want to collect point and date of referral |
| • All sites may want to collect previous participation in CR |
| • All sites may want to collect signs and symptoms of a participant’s cardiac condition(s) and a detailed history of comorbidities |
| • All sites may want to collect more informative data regarding dietary content and eating habits |
| • All sites may want to collect the availability of exercise equipment at home and a gym membership |
| • All sites may want to collect religion |
| • All sites may want to collect the spoken language of participants |
| • All sites may want to collect a participant’s desired occupation status |
| • All sites may want to collect travel distance to CR |
| • All sites may want to collect risk of falling questions |
| • All sites may want to collect attendance for each core component |
| • All sites may want to collect adherence issues for core components at graduation |
| **Objective 3: Michigan Site Data Analysis** |
| • Participants were predominantly Caucasian men with university education |
| • Participants predominantly had more comorbidities and were not actively employed |
| • Having less than university education decreased the likelihood of graduating |
| • Increasing age modestly increased the likelihood of graduating |

### 2.7.1 Phase 1 – Program Characteristics and Database Variables

In both Canadian and United States-based CR models, the following steps occur: 1) an individual with an eligible diagnosis or diagnoses is referred to early outpatient CR, 2) individuals are contacted by a CRP liaison to arrange an intake appointment and undergo an intake assessment of key variables relative to a medical history, demographic information and other influences on health that may pose as barriers to CR participation and completion, a physical evaluation, and an exercise stress test protocol (all variables are collected in a database guided by the database dictionary), 3) the individual then begins an individualized early outpatient CRP, 4) individuals graduate from the early outpatient CRP and at program completion are re-evaluated on key variables (and occasionally at other time-points during the program), 5) after completion (i.e., graduation) of the early outpatient CRP an individual may begin the maintenance phase, 6) in some early outpatient CRPs individuals are evaluated again during long-term follow up (either as part of or separate to a structured maintenance phase; also reflected in the database dictionary).

The examination of the program characteristics and database variables for the four CR sites provided valuable insight into the granular details of all the previously mentioned steps. Moreover, the inclusion of two Ontario sites and two Michigan sites promoted within and between country comparisons of CR models.

**Objective 1: Program Characteristics Description**

As expected, similarities and differences were discovered between the Canadian-based and United States-based sites. This held true when comparing

sites from the same country, yet similarities were most prevalent when sites were located in the same country.

**Program Overview**

All CRPs operated under the auspice of a health care system and were accordingly affiliated with a hospital. The sites in Ontario received funding from the Ministry of Health (i.e., the Government) and participants did not have a program fee as this was covered by provincial health care funding. In Michigan, the programs received commercial or government insurance funding, and program fees and participant co-payments were dependent on the funding source.

Recognizing that financial cost is a barrier to program participation and completion, exploring ways to reduce participant-level cost is important, particularly in the United States.[13–15,23] The Million Hearts Cardiac Rehabilitation Collaborative in the United States (founded by the Centres for Medicare and Medicaid Services and the Centres for Disease Control and Prevention) is composed of a spectrum of individuals involved with CR deliverance (e.g., federal and private sector organizations, CR participants) with the common goal of preventing one million cardiovascular events within five years.[13] This collaborative suggests that to reduce expenses for CR participants, negotiations with insurance companies could occur to minimize out-of-pocket participant expenses, and a charitable fund supported by previous graduates or other donors could be established to provide financial assistance to participants with high-copayments or no insurance.[13,24–26] The complexity of devising plans to share health care costs is widely acknowledged as solutions are constrained by policies and procedures

within the health care system.[24,25] Investigation into smaller scale strategies to reduce financial barriers for participants is warranted.

As part of the program overview, the Ontario sites indicated that the average number of weekly onsite sessions was two with an overall program duration of six months, directly aligning with national guidelines.[8] In the United States, program duration is typically examined in accordance with the number of sessions approved by insurance usually equating to 36 onsite sessions, and commonly occurring three times per week.[7] The Michigan sites offered 2 to 3 weekly onsite sessions that spanned anywhere from 8 to 18 weeks, with the actual program duration typically correlated with the number of insurance approved sessions. Evidently, overall program duration was longer within the Ontario sites suggesting that the Michigan sites could make between country comparisons to determine the number of weekly onsite sessions and overall program length that produces the most favorable outcomes for participants. In the United States, the ideal prescription for insurance to cover would presumably be the minimal amount of sessions needed to achieve benefit, however, this reduction in program duration may appeal to participants (e.g., minimization of financial burden and time-commitment) as well.

**Eligibility for Referral**

In general, the findings of this study provided support for similar referral eligibility criteria on either side of the border.[7,8,10,27] All sites accepted referrals for an array of diagnoses that aligned with mandated eligibility criteria put forth by the CR governing bodies in both Canada and the United States.[7,8,10,27] However, one of the sites (located in Ontario) explicitly stated referral acceptance for acute

coronary syndrome (ACS) and not solely MI, despite ACS being eligible in both countries.[7,8,10,27] This same site uniquely accepted implantable cardioverter-defibrillators and pacemakers following Canadian guidelines, but also accepted cardiac arrhythmias, congenital heart disease, and cardiomyopathies, which were not indicated in national guidelines.[8,28] In Ontario, provincial guidelines also cite "having (a) CVD risk factor(s) only (e.g., hypertension but with no CVD event)" as an accepted criterion for referral, yet neither site appeared to include this participant cohort.[28] One of the sites in Michigan also veered from national guidelines by uniquely accepting left ventricular assist devices and peripheral arterial disease.[7] An explanation for the deviation by these CR sites from the eligibility criteria proposed in guidelines could be that the national guidelines (e.g., CACPR and AACVPR) are outdated (i.e., not within the last 5 years) and as such, the benefit for other participant populations may have since been established (perhaps even within these individual CR sites), and thus updated endorsement and guidelines from governing bodies is required.[7,8] Furthermore, research is warranted to better understand why sites in the same country and within the same province or state would not have identical eligibility criteria. Once within country nuances are justified, between country differences may be examined and the impact of CR on outcomes for cohorts of participants with varying referral indications can be established.

Furthermore, although it is unclear why Ontario sites would not have CVD risk factor-only participants as part of the CR clientele, it could be speculated that since CAD is the second leading cause of death in Canada, the capacity of the

early outpatient CRPs would be quickly surpassed if participants with only CVD risk factors and no CVD event were referred.[3] As these "at risk" individuals would benefit from CR, they could still be identified at both the Ontario and Michigan sites and provided with resources to adopt beneficial lifestyle changes at home, such as improving dietary intake and physical activity. This programming could be considered "pre-habilitation" and insurance coverage, especially in the United States could be advocated. In fact, the CR model has been followed to provide lifestyle interventions to individuals with metabolic syndrome (a group of cardiometabolic risk factors including, but not limited to hypertension, glucose intolerance and high blood insulin levels, hyperlipidemia, and obesity) and has proven to produce positive outcomes by eliminating the prevalence of metabolic syndrome and the related CVD risk factors in individuals.[29–31] Therefore, the chance of CVD and ultimately CAD is reduced.[30,31]

**Referral Details**

A variety of referral procedures were observed across the four sites and most often included both automatic and paper referrals depending on the point of referral. Sites had multiple points of referral, including acute care, inpatients at site-affiliated hospitals, and outpatients at affiliated physician offices. Although beyond the scope of the current study, future work could explore these procedural variations and determine those that elicit maximal referral rates. Consideration of the different health care systems and the related points of referral at each site may also be crucial as deviations of automatic referral could be more beneficial in specific health care settings.

**Core Components**

None of the sites offered participation incentives, but all may want to consider implementing incentives as a strategy to increase rates of program attendance and completion.[13,32] The benefit of this was demonstrated when a CRP at the Mayo Clinic (Rochester, Minnesota, United States) implemented a motivational program which included participants receiving specific prizes (e.g., parking pass, T-shirt, tote bag) after every sixth session attended, and staff members receiving similar prizes for promoting participant success.[32] The median number of sessions attended increased by three.[32] The sites in this study could design cost-effective incentive programs for their cohorts of participants and test their effectiveness.

**Exercise Training Details**

In the current study, all sites conducted an exercise test to guide exercise-related programming at intake. However, one of the Michigan sites conducted exercise tests on only 50% of participants. Three of the sites measured maximal $VO_2$, whereas one of the sites estimated this measurement with submaximal exercise testing protocols. The utilization of exercise testing could be discussed among the sites to understand individual rationales for exercise testing and discuss the merits and disadvantages of existing procedures in CR populations.

ECG-monitoring or telemetry use during exercise occurred across the sites in Michigan, but not in Ontario. One Michigan site indicated its use for the first three exercise sessions then discontinuation until clinical need, whereas the other Michigan site transitioned to discontinuation when insurance approval was granted

and in the absence of signs and/or symptoms. The slight nuance between the Michigan sites warrants further examination. It may be worthwhile for the Michigan sites to consider following the “use as needed” format as per the Ontario-based sites. This change would require approval from insurance providers, but it may reduce programming costs and lessen participant burden.

**Data Collection Time-Points**

All sites collected data at intake and graduation. Three of the sites collected data from participants at different time points during CR programming, yet only one of these sites (an Ontario site) collected data that mirrored intake. This comprehensive assessment was only conducted when warranted. All sites may want to consider collecting data during programming to determine if individualized programs need to be adjusted throughout the duration of early outpatient CR participation to maximize adherence and benefit.

One of the Michigan sites collected data from participants at multiple time points following graduation (1, 6, and 12 months after graduation, then following every 6 months thereafter), delivering an assessment similar to that at intake. The other sites may want to adopt such follow-up procedures, as these align with national guidelines, and provide valuable information on the maintenance of benefits.[7] As implementation of lifestyle changes diminishes within 3 to 6 months following early outpatient CR, this may provide insight into the challenges experienced by graduates and provide a platform to create strategies for improvement from both a provider and participant perspective.[7] Additionally, post-graduation follow-up would be a primitive way of implementing and tracking home-

based programming for participants following graduation as part of the maintenance phase.

**Staff Members**

All sites had a medical director who is a physician. However, there was variation in the designation of the program director, as well as the number of and amount of participant interaction with exercise physiologists/kinesiologists, dietitians, and nurses. These differences may be attributed to the funding that the programs receive or the capacity the programs have for participants but could nonetheless be a point of discussion between the sites to determine an ideal participant to staff ratio. One site had a psychologist, whereas the other three sites did not, and as such, an appointment with a psychologist is typically provided following a referral. Considering that psychological and social factors (e.g., depression, anxiety, stress) are modifiable CVD risk factors that can negatively impact disease progression following a cardiac event, perhaps all sites could consider having a psychologist on staff to eliminate the wait time of referrals.[33,34] However, two of the sites without a psychologist did have a social worker/behaviourist/stress management personnel on staff and the other site referred participants to these services so this may also assist with psychosocial management. It is important to recognize that these specialties require substantial monetary support and may thus not be feasible.

**Home-Based Programming**

Three of the four sites offered home-based programming to participants, yet all administered slightly different programs. Innovative program components of

one of the Michigan-based sites involved live two-way audio and video conferencing and online presentations for delivery of core components. Thus, home-programming is yet another area where the sites could converse about implemented methods. Future work could investigate the strengths and weaknesses of these protocols as predictors of participant success, while ascertaining the associated cost implications.

## Objective 2: Common and Unique Database Variables

Numerous common and unique variables were identified in the database variables collected across the four sites.

### Variables Collected at Intake

#### *Referral and General Intake*

Only the Ontario sites collected the point of referral. As referral rates are suboptimal in Canada and the United States, the Michigan-based sites may benefit from collecting this information, with future research exploring the potential shortcomings of specific referral locations (e.g., inpatient unit, cardiac diagnostics/intervention unit, physician office).[13,14] Similarly, only the Ontario sites collected date of referral. This is important information for calculating governing-body benchmarks for post-discharge CR enrollment (i.e., Canada - 30 days, United States - 21 days) and something for all sites to consider collecting.[9,10] Strategies for maximizing referral and achieving mandated benchmarks at all sites could then be designed, implemented and investigated. Moreover, a unique variable collected by one of the Michigan sites was previous participation in CR. This variable may

be of interest to the other sites as well, and future work could determine its impact on program attendance and completion, as well as clinical outcomes.

### ***Medical History***

The database dictionaries varied across the sites in the extent that medical history related variables were collected at intake, ranging from “essential only” to “very comprehensive”. All sites collected the event or indication for referral to early outpatient CR, which is valuable for determining if participants with specific diagnoses (e.g., CABG) are more likely to participate than others in the modern era of CR, where CR utilization is endorsed in both countries for an array of diagnoses.[16–18] All sites also collected the diagnoses of hypertension and diabetes, and prescribed medications. A unique variable collected by one of the Michigan-based sites was the signs and symptoms of a participant’s cardiac condition(s). This could be beneficial for all sites to collect as an indication of secondary events that may occur during the exercise training component of CR (that is if approval for exercise training is granted following the intake assessment). The same Michigan site uniquely collected gynecological, family, and an extensive comorbidity history, the latter of which could be beneficial for all sites to collect in effort to identify and overcome barriers to CR participation and completion (please see page 130 for additional discussion).

There were no common variables identified among the sites to evaluate the dietary content and eating habits of participants. One Michigan site collected information regarding what the participant considered a healthy weight to be for themselves, previous or current weight-loss programs, previous dietician

counselling, and motivation, confidence and obstacles to improving dietary intake. These variables provide value and insight into the anthropometrical measurement of weight, rather than simply collecting an objective number. Furthermore, collection of dietary content and eating habits may be useful when referring participants to nutritional counselling and weight management programs. Considering these are core components of early outpatient CR in both countries, all sites may want to collect these variables.[7,8]

There was inconsistency in how emotional and psychosocial health was assessed across the sites. Overall, different assessments were employed for depression and anxiety, with little focus on stress. Future studies could examine the most efficient method of assessment.

Once again, there is variation in how relative variables for physical activity or exercise patterns are collected. Due to their broad nature, recommending specifics on what habitual exercise-related data should be collected across sites is beyond the scope of this study, and warrants further collaborative investigation by the sites. Having said that, a unique set of variables collected at one of the Michigan sites is worth considering for immediate collection across all sites: “exercise equipment at home” and “membership to a gym”. This information may inform off-site exercise training options, which is especially important in an era where hybrid and home-based CR programming is gaining endorsement.[35–37]

Three sites (the Ontario sites and one Michigan site) collected variables at intake reflective of alcohol consumption, however a unique variable collected by a Michigan site was “the motivation to quit drinking alcohol from a 0-10 scale”.

Identifying current status of consumption and quantifying motivation to change guides referrals and subsequent CR-related programming, including psychological and/or nutritional counselling and goal-setting, all representing vital aspects of early outpatient CR.[7,8]

Current tobacco smoking status was collected by all sites in the study, although there was variation in the variables collected across the sites in relation to details of tobacco use. Future work could aim to determine which of these assorted variables, if any, predicts success of smoking cessation. This would streamline data collection and may guide the delivery of tobacco cessation services.

### ***Demographic Information and Barriers to CR Participation and Completion***

All sites collected a variation of demographic information. When collecting sex, some sites use the term sex interchangeably with gender. In the modern era of gender identification, a distinction between the two terms should be made to be inclusive to all participants. Future studies could examine specific barriers to CR participation and completion that participants with different gender identities may experience and/or the potential for increased risk of CVD progression (i.e., novel findings have suggested that hormone therapy may proliferate CVD risk factors).[38]

The Muslim religion has previously been identified as a potential barrier that prevents women from participating in CR, yet only one site (a Michigan-based site) collected participants' religions.[17,39] Moving forward, the influence of other religions may be important to explore, and strategies to remove this barrier to CR

participation and completion can be employed (e.g., women-only exercise training classes, sex and/or religion-exclusive social support by CR staff members).[7,13]

Linguistic abilities for non-English native speakers have been identified as a barrier to CR participation and completion.[19,21] The Ontario sites collected this information, but it may be helpful for the Michigan sites to collect spoken language of participants as well. Suggested strategies to overcome this barrier to participation and completion could then be explored, such as providing supplemental written material in varying languages, having interpreter services, or having bilingual staff members.[7,8] It would, however, be important to determine the cost-benefit ratio of these interventions.

It is promising that three sites (two Ontario sites and a Michigan site) collected information on education and occupation, as these are known barriers to CR participation and completion.[15,17,18] A unique variable collected by the Ontario sites was the participant's desired occupation status. Goal-setting is a major aspect of early outpatient CR in both Canada and the United States, and thus the collection of a participant's desired occupation status by all sites would be beneficial. Not only would attainment of desired occupation status provide insight into whether returning to work is a participant's priority and adjust programming accordingly (e.g., offer vocational counselling), it could also serve as a goal to promote CR attendance by emphasizing that CR participation can increase the rate of returning to work.[7,8] While one Michigan site collected participants' insurance information, all sites could consider collecting a variable more relevant to a participant's financial situation such as annual income. Sites will then be able

to identify participants who may experience financial burdens that impede CR participation and completion and then employ strategies to help combat financial barriers. This is especially important for the Michigan sites, where early outpatient CR is not entirely covered by funding sources like it is for the sites in Ontario.

Three of the sites (Ontario sites and one Michigan site) collected living situation and marital status, while the Michigan-based sites collected additional social support information. Moving forward, all sites may want to obtain collective social support information, which could be used in a future study to determine predictors of program completion concomitant to the efficacy of strategies (e.g., buddy system, carpooling) designed to increase social support.[7]

It is promising that the Ontario sites collected travel distance information at intake. By doing so, increased travel distance as a barrier to participation and completion can be identified immediately, and strategies (e.g., hybrid or home-based programming) implemented to promote participant success.[35–37] Thus, it would be worthwhile for all sites to consider collecting travel distance and/or travel time to CR sites.

### ***Physical Evaluation***

All sites collected vital signs and anthropometric data in a similar manner, yet there was variation in how physical status was assessed. It is unclear if these differences are meaningful, and it is recommended that expert analysis be conducted to determine the most suitable and efficient variables to collect. A key difference worth noting pertained to risk of falling, the information of which was

collected by one Ontario site. Risk of falling is an important safety factor and may be something all sites may want to collect at intake.

### ***Exercise Test***

There were many similar variables collected by the sites with respect to the exercise test. Three of the sites (two Ontario sites and a Michigan site) collected the reason for termination. This information may provide a platform for future research studies investigating common causes of exercise test termination, and guide future "accommodated" CR programming. A unique variable collected by a Michigan site was the 6-minute hall walk score. This may be an important testing consideration for the other sites, at it could be a viable economical option to use for participants who have limiting factors that prevent completion of maximal and submaximal exercise tests, but still require an individualized exercise training programming.[7,8,28]

### ***Questionnaires***

Sites used varying questionnaires to collect information on overall health, psychological health, physical health, and nutrition. A modern standardized questionnaire or a battery of questionnaires for CR participants could be fostered using expertise from across the sites.

### ***Staff Members***

Three sites (two Ontario sites and a Michigan site) noted the assigned participant case manager. This is something to consider for all sites, as consistency in care may be an important indicator for participant success.

## Variables Collected During Programming

### *Attendance*

All sites in the current study collected attendance data, although the format differed. For example, the Ontario sites collected attendance rates for specific core program components, whereas the Michigan sites generalized by collecting the total number of sessions attended. It may be beneficial for all sites to collect attendance information across the components and use this information during in-program evaluation sessions to potentially intervene and employ strategies to increase attendance for all core components.

## Variables Collected at Graduation

The only identical variable collected across sites was an exit exercise test. One Ontario site and one Michigan site administered graduation assessments that almost mirrored intake assessment procedures and is something all sites may want to consider to best evaluate both participant and program success. Similar to intake, sites collected varying questionnaires on overall health, psychological health, physical health, and nutrition. Once again, a modern standardized questionnaire or a battery of questionnaires could be created. A program evaluation was also administered by one of the Michigan sites, and may be considered useful by the other sites to evaluate the program quality from a participant perspective.

One Michigan site collected if participants are having trouble adhering to the components of CR (e.g., taking prescribed medication, getting regular exercise, quitting smoking). This provides valuable insight into what adaptations

can be made to help the participant better address personal needs and discharge the participant with the appropriate tools for transition into a less-interactive maintenance program, or independent management of health behaviours.[7,8] Three sites (two Ontario sites and a Michigan site) collected the reason a participant graduated or ceased to attend CR (e.g., completed program, insurance, return to work). As completion rates in Canada and the United States are suboptimal, collecting this information on why participants are not completing CR is worthwhile.

### 2.7.2 Phase 2 – Michigan Site Data Analysis

As previously mentioned, the benefits of CR are well-known, yet participation and completion rates for CR are suboptimal.[6,13,14] To date, evidence suggests that older participants, women, minorities, those with a lower socioeconomic status (i.e., lower education, unemployed, lower income), participants having numerous comorbidities, and participants referred for an indication other than CABG are less likely to participate in and/or complete CR.[15–20,22] Subsequent strategies to overcome these barriers have been suggested[13,19], but future research work is warranted for multiple reasons: 1) there is still a need to improve participation and completion rates, and 2) available evidence provides conflicting results, was minimally studied and/or was performed in an older era of CR programming.

Phase 2 of this study was a first step in addressing these gaps in the literature. Specifically, this study characterized a participant cohort in a modern era early outpatient CRP housed on the United States-side of our Great Lakes Central

Region, and identified participant factors that impacted graduation (i.e., program completion).

As expected, participants were predominantly Caucasian, and were highly educated men, yet were older in age, had a greater prevalence of comorbidities, were not actively employed, and PCI or stent was the primary indication for referral. Significant predictors of program completion were age and education. Findings are discussed in detail below. It is important to note that this early work is reflective of United States-based programming and may not be generalizable to Canadian-based programs, despite close geographical proximity in our Great Lakes Central Region.

**Characterization of the Population**

In alignment with previous studies, the participants in this study were predominantly Caucasian men with higher education (e.g., university).[15–17,21,22] Therefore, implementation of strategies to encourage participation of racial minorities, women, and those with lower levels of education is warranted for this early outpatient CRP. Contrary to the hypothesis and to previous work, the current population was on average older, with more comorbidities, not actively employed, and referred for PCI or stent.[15–18] Future research could assess the tactics used within this CRP that endorsed participation of older participants and those with more comorbidities and then apply these strategies to other CRPs. Moreover, strategies to encourage younger participants and those with fewer comorbidities to participate could also be explored and employed. Additionally, factors impacting

the participation for different referral indications and actively employed participants could be explored as well.

## Participant Factors and Program Completion

### Age

When examining the logistic regression model, each yearly increase in age was associated with a slight 1.6% increase in the likelihood of graduating. Previous research has presented older age as a barrier to participation and completion, but the effect of age may actually be more fluid in regard to CR participation and completion.[15–18] For instance, a recent systematic review of the factors associated with non-participation in, and dropout from, CRPs showed contrasting results.[17] In essence, drop-out rates varied in the studies examined, increasing for both older and younger participants.[17] Additionally, a recent study in the United States that utilized data from the Behavioral Risk Factor Surveillance System (Centres for Disease Control and Prevention; 2005 to 2015) concluded that participation in CR was more likely for participants who were 65 years of age or greater compared to younger participants who were 18 to 54 years of age (OR 1.787, 95% CI 1.540 to 2.074, $p < 0.0001$).[40]

Despite the findings from this study representing age only modestly increasing the likelihood of graduating in the logistic regression model, the prevalence of older participants completing the program may be explained by the greater time availability they experience, especially as they approach and enter retirement. As speculated, it was determined that the retired participants were significantly older in age compared to those who were actively employed. Similarly,

the previously mentioned Behavioral Risk Factor Surveillance System study concluded that retired or self-employed participants were more likely to participate in an early outpatient CRP, perhaps due to schedule flexibility.[40]

Therefore, it is important that younger participants, especially those who have more time commitments (e.g., employment obligations) are identified during the intake assessment, and that accommodations are made for the participants' schedules, such as implementing and prescribing hybrid or home-based programming to encourage participation and completion.[35–37] However, this Michigan site does not offer these alternative forms of CR programming and may want to discuss with the other Michigan site how to deliver programming and overcome the associated cost implications for participants in the United States.[37] The site could also consider adopting an adaptable on-site program schedule incorporating early morning, after work, or weekend hours to accommodate a participant's commitments; that is if the addition of hours of operation does not pose a financial burden on the CRP.[13]

**Education**

The logistic regression model also revealed that compared to holding a university education, high school or less education and college/post-secondary education decreased the likelihood of graduating by 56.5% and 48.2%, respectively. These findings align with previous research that suggested participants with higher education are more likely to participate in and/or complete programming.[15,17]

The first possible explanation for these findings is that with higher education, individuals secure higher paying jobs, leading to financial and retirement stability.[41,42] Therefore, participants with higher education do not experience the financial barrier to completing CR as they have the monetary funds to override non-universal healthcare coverage in the United States and to participate even when retired.[41,43]

Secondly, the skills obtained from pursuing higher education (e.g., critical thinking, problem solving, perseverance) are viewed as transferable to taking care of one's health.[42,44] Therefore, in relation to the current study, graduates may possess this perception of power to control one's health.[42,44]

The intake assessment is crucial in identifying participants who have a lower education; therefore, education should continue to be collected in the site's database. If a participant is lacking the skills to feel in control of one's health, extra time can be spent educating the participant on CVD risk factor management and self-care, and goal-setting can be used to provide the perception of power and control.[7,8]

**Occupational Status**

While more weight should be given to the results of the multivariate analysis, the findings of the univariate analysis for occupation status and graduation status are still important to discuss. In this CR cohort, there was a significantly higher proportion of participants graduating who were retired compared to non-graduates. These findings are in contrast to the majority of previous research which suggested that participants who are employed are more

likely to participate.[15,18] As such for this cohort of participants, similar strategies as those proposed for younger participants (e.g., home-based programming, adaptable on-site program schedules) could be used to promote program completion for participants who are not retired, as time-availability is the suspected barrier to participation and completion.[13,35–37]

A significantly lower proportion of participants who were medically disabled graduated compared to those who did not graduate. Despite the low prevalence of participants who are medically disabled in this cohort, this statistically significant finding is still worth mentioning because program completion should be maximized for all participants. As such, these findings align with the majority of previous research that suggested individuals who are employed are more likely to participate.[15,18] The definition for disability presented by the United States Government in regards to the benefits provided for individuals with disabilities is: "the inability to engage in any substantial gainful activity by reason of any medically determinable physical or mental impairment(s) which can be expected to result in death or which has lasted or can be expected to last for a continuous period of not less than 12 months."[45] Evidently, if a participant has difficulty completing activities and is very low functioning, transportation to CR and program attendance will be a burden. Additionally, while participants could be receiving financial support (e.g., Social Security, Medicaid, Medicare), the participants are still unemployed so the financial burden of participating in CR could impact completion as well.[15,23]

The strategies suggested for encouraging program completion of participants with a high prevalence of comorbidities (please see below) could also

be applied to improve completion of participants identified as medically disabled, such as home-based programming if the participants are homebound.[13,35–37]

**Comorbidities**

Notably, comorbidities were trending towards significance as a predictor variable in the logistic regression. As the data suggested, the proportion of graduates that had more than two comorbidities was significantly less than the proportion that did not graduate. These findings align with recent reviews of CR, and it has been suggested that higher rates of comorbidities (e.g., depression, stroke, COPD) are related to early drop-out from CR.[15,17,46]

Unmistakably, CR is modeled to manage CVD risk factors, however the basis of the model can improve the status of the majority of chronic diseases.[47] Therefore, it is important that a participant with multiple comorbidities is encouraged to stay in CR to learn how to manage one's health and better one's overall HRQoL.[48] Conclusively, comorbidities (i.e., chronic diseases) cannot be treated independently and thus this site should strive to apply the rehabilitation aspect of CR to all chronic diseases, not solely CVDs. With that said, the intake assessment is once again vital in flagging participants with a high prevalence of comorbidities at intake. Notably, this Michigan site collects an extensive list of comorbidities and should continue this practice.

It is also important to evaluate at intake how CR could be viewed as an inconvenience for the participant, adding to the participant's perceived disease burden. This emphasizes the importance of individualized programs in CR so participants with multiple comorbidities can have personal goals and preferences

heard and accounted for with respect to the delivery of care. Another way to reduce the burden for participants is to ensure coordinated care. It is important that CR staff members are in communication with other health care providers that are part of the participant's overall care plan to provide maximum standard of care treatment.[49] Furthermore, if participants are homebound, perceived burden could also be reduced by offering adapted or usual home-based programming to minimize transportation or accessibility issues.[13,35,37] Once again, this Michigan site may want to discuss the logistics of alternative programming with the other Michigan site.

A statistically significant difference was also observed between age and the number of comorbidities, suggesting that older participants have more comorbidities. It is predictable that older aged participants are diagnosed with more comorbidities, but what is unexplained is the opposite effect that age and comorbidities have on graduation status, despite participants with greater than two comorbidities being the oldest aged cohort in this study. It is possible that the numerous burdens of having multiple comorbidities outweigh the benefit of time availability acquired with retirement. With multiple comorbidities and the accumulated impairments, along with the prescription of numerous medications and the potential negative interactions of medications, participants likely feel overwhelmed and burdened.[50] Having more comorbidities will ultimately reduce a participant's functionality and increase frailty, which are important aspects to consider as well when promoting early outpatient CR participation and completion.[49]

**Sex**

In contrast, sex did not have a significant association with graduation status. This is surprising as it is established in the literature that women are less likely to participate and complete programming.[15–20] Despite the non-significant findings between sex and graduation status, when further examining this cohort of participants, there are over two times as many men compared to women. With this said, once women enroll in this early outpatient CRP, they may have the same probability as men to complete (e.g., within each sex approximately three quarters of participants completed programming). Therefore, the barriers for women to complete this program could potentially arise during the referral process and enrollment stage. There have been numerous barriers suggested that prevent women from being referred to and enrolling in early outpatient CR, such as lack of physician endorsement, misconceptions of exercise and CR, and family obligations.[19] However, it is important to identify barriers for this specific cohort of participants and the impact of local factors to develop equal representation of men and women within this program.[19]

**Race**

Furthermore, race was not significantly associated with graduation status. Previous research has suggested that Caucasians are more likely to participate, whereas individuals identifying as a minority prevents participation and/or program completion.[16,21,22] Due to race not having an impact on program completion, characteristics of this early outpatient CRP that promote participation and completion of participants who are minorities should be identified and shared with

other sites that may experience race as a barrier. However, it should be noted that this cohort of participants was predominantly Caucasian, as discussed earlier, which could be explained by the location of this site (i.e., the majority of the residing population is Caucasian). Therefore, the low representation of races other than Caucasian in this early outpatient CRP may be simply a result of participants who are another race not residing in the vicinity of the program, and unlike sex, it is not due to the cohort of participants being uncommonly referred or enrolled to this CRP.

**Referral Indication**

In contrast to previous research that suggested participants who had CABG were more likely to participate and/or complete programming, referral indication was not associated with graduation status.[17,18] These findings indicate that this early outpatient CRP may decide to focus its energy on overcoming other barriers to participation and completion of programming. Moreover, if this program implements specific strategies to foster the participation and completion of all eligible diagnoses then this information should be further investigated and broadly shared with other sites with similar participant cohorts and program characteristics.

## 2.8 Conclusion

This study took an important first step toward establishing a CR model or models that is/are most efficient for all cohorts of participants in varying Ontario and Michigan based sites. Through examination of the "granular" details of each site it was determined that all sites may want to consider implementing specific program characteristics to maximize participant benefit, such as "pre-habilitation"

programs for individuals at risk of developing CVD and participation incentives for those completing early outpatient CR. Moreover, differences between the sites (e.g., the use of telemetry) warrant further investigation. While changes in program characteristics should ultimately be adopted to benefit participants, the cost implications of all program changes need to be considered to minimize financial burden, especially for Michigan sites. As such, the expertise from all sites should be leveraged to develop strategies that not only provide participant benefit, but also cost-efficient solutions.

Nonetheless, strategies may also need to be specific to certain cohorts of participants, especially those that may have factors that hinder their CR participation and completion. Therefore, while all sites collected vital information in their databases regarding participants, certain differences emerged suggesting that all sites may want to collect aspects such as a participant's: status of previous CR participation, extensive comorbidity history, religion, spoken language, desired occupation status, travel distance, availability of exercise equipment at home or membership to a gym, and adherence issues with CR components. Additionally, all sites may want to also consider the importance of collecting all-encompassing participant data not only at intake and program completion, but during programming as well.

Through collection of participant information, factors that impede program completion may be better understood. Using historical participant data from one site, the current study shed light on characteristics of their participant cohort that were both expected and unexpected. These insightful findings highlight the benefit

of conducting a larger scale study with data from all sites. This would not only allow for within site exploration, but it would foster the ability to examine regional similarities and differences in CR populations.

It became clear that increasing age and obtaining higher education were associated with program completion in this cohort, with age only modestly increasing the likelihood of completing programming. Overall, not all factors in the logistic regression model were associated with graduation status, therefore other factors need to be explored (e.g., annual income, insurance coverage, transportation, travel distance, time-availability, social support). Since sex and race were not associated with program completion, these findings may suggest that the site is appropriately providing resources to women and participants who identify as minorities to complete programming.

Overall, this research laid the foundation for within and between country comparisons across the four involved sites and can lead preliminary discussions to strategize the next steps to the development of an ideal CR model or models for all participants.

## References


1. WHO. Cardiovascular diseases (CVDs). World Health Organization. https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds). Published 2017. Accessed January 4, 2019.

2. WHO. The top 10 causes of death. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death. Published 2018. Accessed January 4, 2019.

3. Public Health Agency of Canada. *Report from the Canadian Chronic Disease Surveillance System: Heart Disease in Canada, 2018*; 2018. http://publications.gc.ca/collections/collection_2018/aspc-phac/HP35-85-1-2018-eng.pdf. Accessed January 4, 2019.

4. Benjamin EJ, Virani SS, Callaway CW, et al. Heart disease and stroke statistics—2018 update: A report from the American Heart Association. *Circulation*. 2018;137:e67-e492. doi:10.1161/CIR.0000000000000558.

5. Hamm LF, Sanderson BK, Ades PA, et al. Core competencies for cardiac rehabilitation/secondary prevention professionals: 2010 Update. *J Cardiopulm Rehabil Prev*. 2011;31:2-10. doi:10.1097/HCR.0b013e318203999d.

6. Anderson L, Thompson DR, Oldridge N, et al. Exercise-based cardiac rehabilitation for coronary heart disease. *Cochrane Database Syst Rev*. 2016;(1). doi:10.1002/14651858.CD001800.pub3.

7. AACVPR. *Guidelines for Cardiac Rehabilitation and Secondary Prevention Programs*. 5th ed. Champaign, Illinois: Human Kinetics; 2013.

8. CACR. *Canadian Guidelines for Cardiac Rehabilitation and Cardiovascular Disease Prevention: Translating Knowledge into Action*. 3rd ed. Winnipeg, Man.: Canadian Association of Cardiac Rehabilitation; 2009.

9. Grace SL, Poirier P, Norris CM, Oakes GH, Somanader DS, Suskin N. Pan-Canadian development of cardiac rehabilitation and secondary prevention quality indicators. *Can J Cardiol*. 2014;30:945-948. doi:10.1016/j.cjca.2014.04.003.

10. Thomas RJ, Balady G, Banka G, et al. 2018 ACC/AHA clinical performance and quality measures for cardiac rehabilitation: A report of the American College of Cardiology/American Heart Association Task Force on performance measures. *Circ Cardiovasc Qual Outcomes*. 2018;11:1-29. doi:10.1161/HCQ.0000000000000037.

11. Grace SL, Parsons TL, Duhamel TA, Somanader DS, Suskin N. The quality of cardiac rehabilitation in Canada: A report of the Canadian Cardiac Rehab Registry. *Can J Cardiol*. 2014;30:1452-1455. doi:10.1016/j.cjca.2014.06.016.

12. Pack QR, Squires RW, Lopez-Jimenez F, et al. Participation rates, process monitoring, and quality improvement among cardiac rehabilitation programs in the United States: A national survey. *J Cardiopulm Rehabil Prev*. 2015;35:173-180. doi:10.1097/HCR.0000000000000108.

13. Ades PA, Keteyian SJ, Wright JS, et al. Increasing cardiac rehabilitation participation from 20% to 70%: A road map from the million hearts cardiac rehabilitation collaborative. *Mayo Clin Proc*. 2017;92:234-242. doi:10.1016/j.mayocp.2016.10.014.

14. Grace SL, Turk-Adawi K, Santiago de Araújo Pio C, Alter DA. Ensuring cardiac rehabilitation access for the majority of those in need: A call to action for Canada. *Can J Cardiol*. 2016;32:S358-S364. doi:10.1016/j.cjca.2016.07.001.

15. Ruano-Ravina A, Pena-Gil C, Abu-Assi E, et al. Participation and adherence to cardiac rehabilitation programs. A systematic review. *Int J Cardiol*. 2016;223:436-443. doi:10.1016/j.ijcard.2016.08.120.

16. Suaya JA, Stason WB, Ades PA, Normand S-LT, Shepard DS. Cardiac rehabilitation and survival in older coronary patients. *J Am Coll Cardiol*. 2009;54:25-33. doi:10.1016/j.jacc.2009.01.078.

17. Resurrección DM, Moreno-Peral P, Gómez-Herranz M, et al. Factors associated with non-participation in and dropout from cardiac rehabilitation programmes: A systematic review of prospective cohort studies. *Eur J Cardiovasc Nurs*. 2019;18:38-47. doi:10.1177/1474515118783157.

18. Beauchamp A, Worcester M, Ng A, et al. Attendance at cardiac rehabilitation is associated with lower all-cause mortality after 14 years of follow-up. *Heart*. 2013;99:620-625. doi:10.1136/heartjnl-2012-303022.

19. Supervía M, Medina-Inojosa JR, Yeung C, et al. Cardiac rehabilitation for women: A systematic review of barriers and solutions. *Mayo Clin Proc*. 2017;92:565-577. doi:10.1016/j.mayocp.2017.01.002.

20. Martin B-J, Hauer T, Arena R, et al. Cardiac rehabilitation attendance and outcomes in coronary artery disease patient. *Circulation*. 2012;126:677-687. doi:10.1161/CIRCULATIONAHA.111.066738.

21. Midence L, Mola A, Terzic CM, Thomas RJ, Grace SL. Ethnocultural diversity in cardiac rehabilitation. *J Cardiopulm Rehabil Prev*. 2014;34:437-444. doi:10.1097/HCR.0000000000000089.

22. Valencia HE, Savage PD, Ades PA. Cardiac rehabilitation participation in underserved populations: Minorities, low socioeconomic, and rural residents. *J Cardiopulm Rehabil Prev*. 2011;31:203-210. doi:10.1097/HCR.0b013e318220a7da.

23. Neubeck L, Freedman SB, Clark AM, Briffa T, Bauman A, Redfern J. Participating in cardiac rehabilitation: A systematic review and meta-synthesis of qualitative data. *Eur J Prev Cardiol*. 2012;19:494-503. doi:10.1177/1741826711409326.

24. Sinnott S-J, Buckley C, O′Riordan D, Bradley C, Whelton H. The effect of copayments for prescriptions on adherence to prescription medicines in publicly insured populations; A systematic review and meta-analysis. Postma M, ed. *PLoS ONE*. 2013;8:e64914. doi:10.1371/journal.pone.0064914.

25. Choudhry NK, Avorn J, Glynn RJ, et al. Full coverage for preventive medications after myocardial infarction. *N Engl J Med*. 2011;365:2088-2097. doi:10.1056/NEJMsa1107913.

26. Keteyian S, Relyea B, Blount M, Bryant S. The design and philosophy of a hospital- and community-based comprehensive cardiac rehabilitation program. *J Cardiopulm Rehabil Prev*. 1985;5:492-495.

27. Balady GJ, Ades PA, Bittner VA, et al. Referral, enrollment, and delivery of cardiac rehabilitation/secondary prevention programs at clinical centers and beyond: A presidential advisory from the American Heart Association. *Circulation*. 2011;124:2951-2960. doi:10.1161/CIR.0b013e31823b21e2.

28. CCN. *Standards for the Provision of Cardiovascular Rehabilitation in Ontario*.; 2014. https://www.crno.ca/news/23-2014-ccn-standards-for-the-provision-of-cardiovascular-rehabilitation-in-ontario.

29. Zipes D, Libby P, Bonow R, Mann D, Tomaselli G, Braunwald E. *Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine*. 11th ed. Philadelphia, Pennsylvania: Elsevier; 2018.

30. Walden P, Rubenfire M, Jackson E, Oral E, Jiang Q, Weintraub M. Assessing the incremental benefit of an extended duration lifestyle intervention for the components of the metabolic syndrome. *Diabetes Metab Syndr Obes Targets Ther*. 2016;9:177-184. doi:10.2147/DMSO.S94772.

31. Rubenfire M, Mollo L, Krishnan S, et al. The metabolic fitness program: Lifestyle modification for the metabolic syndrome using the resources of cardiac rehabilitation. *J Cardiopulm Rehabil Prev*. 2011;31:282-289. doi:10.1097/HCR.0b013e318220a7eb.

32. Pack QR, Johnson LL, Barr LM, et al. Improving cardiac rehabilitation attendance and completion through quality improvement activities and a motivational program. *J Cardiopulm Rehabil Prev*. 2013;33:153-159. doi:10.1097/HCR.0b013e31828db386.

33. Cohen BE, Edmondson D, Kronish IM. State of the art review: Depression, stress, anxiety, and cardiovascular disease. *Am J Hypertens*. 2015;28:1295-1302. doi:10.1093/ajh/hpv047.

34. Steptoe A, Kivimäki M. Stress and cardiovascular disease: An update on current knowledge. *Annu Rev Public Health*. 2013;34:337-354. doi:10.1146/annurev-publhealth-031912-114452.

35. Anderson L, Sharp GA, Norton RJ, et al. Home-based versus centre-based cardiac rehabilitation. *Cochrane Database Syst Rev*. 2017;(6). doi:10.1002/14651858.CD007130.pub4.

36. Gabelhouse J, Eves N, Grace SL, Reid RC, Caperchione CM. Traditional versus hybrid outpatient cardiac rehabilitation: A comparison of patient outcomes. *J Cardiopulm Rehabil Prev*. 2018;38:231-238. doi:10.1097/HCR.0000000000000253.

37. Thomas RJ, Beatty AL, Beckie TM, et al. Home-based cardiac rehabilitation. *J Am Coll Cardiol*. 2019;74:133-153. doi:10.1016/j.jacc.2019.03.008.

38. Streed CG, Harfouch O, Marvel F, Blumenthal RS, Martin SS, Mukherjee M. Cardiovascular disease among transgender adults receiving hormone therapy: A narrative review. *Ann Intern Med*. 2017;167:256-267. doi:10.7326/M17-0577.

39. Chauhan U, Baker D, Lester H, Edwards R. Exploring uptake of cardiac rehabilitation in a minority ethnic population in England: A qualitative study. *Eur J Cardiovasc Nurs*. 2010;9:68-74. doi:10.1016/j.ejcnurse.2009.10.003.

40. Peters AE, Keeley EC. Trends and dors of participation in cardiac rehabilitation following acute myocardial infarction: Data from the Behavioral Risk Factor Surveillance System. *J Am Heart Assoc*. 2018;7:e007664. doi:10.1161/JAHA.117.007664.

41. Tamborini CR, Kim C, Sakamoto A. Education and lifetime earnings in the United States. *Demography*. 2015;52:1383-1407. doi:10.1007/s13524-015-0407-0.

42. Zajacova A, Lawrence EM. The relationship between education and health: Reducing disparities through a contextual approach. *Annu Rev Public Health*. 2018;39:273-289. doi:10.1146/annurev-publhealth-031816-044628.

43. Schröder SL, Richter M, Schröder J, Frantz S, Fink A. Socioeconomic inequalities in access to treatment for coronary heart disease: A systematic review. *Int J Cardiol*. 2016;219:70-78. doi:10.1016/j.ijcard.2016.05.066.

44. Mirowsky J, Ross CE. Education, health, and the default American lifestyle. *J Health Soc Behav*. 2015;56:297-306. doi:10.1177/0022146515594814.

45. United States Government. Disability Evaluation Under Social Security. Social Security Administration. https://www.ssa.gov/disability/professionals/bluebook/general-info.htm. Published 2019. Accessed July 24, 2019.

46. Pardaens S, De Smedt D, De Bacquer D, Willems A-M, Verstreken S, De Sutter J. Comorbidities and psychosocial characteristics as determinants of dropout in outpatient cardiac rehabilitation. *J Cardiovasc Nurs*. 2017;32:14-21. doi:10.1097/JCN.0000000000000296.

47. Arena R, Ozemek C, Laddu D, et al. Applying precision medicine to healthy living for the prevention and treatment of cardiovascular disease. *Curr Probl Cardiol*. 2018;43:448-483. doi:10.1016/j.cpcardiol.2018.06.001.

48. Listerman J, Bittner V, Sanderson BK, Brown TM. Cardiac rehabilitation outcomes: Impact of comorbidities and age. *J Cardiopulm Rehabil Prev*. 2011;31:342-348. doi:10.1097/HCR.0b013e31822f189c.

49. Holland AE, Lee AL. Precision medicine, healthy living and the complex patient: Managing the patient with multimorbidity. *Prog Cardiovasc Dis*. 2019;62:29-33. doi:10.1016/j.pcad.2018.12.010.

50. Petrillo LA, Ritchie CS. The challenges of symptom management for patients with multimorbidity in research and practice: A thematic review. *Prog Palliat Care*. 2016;24:262-267. doi:10.1080/09699260.2016.1192320.

# Appendices

## Appendix A: Missing Cases

| Statistics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Graduation Status | Gender | Education | Occupation Status | Comorbidities | Referral Indication | Race |
| N | Valid | 1263 | 1265 | 1263 | 1265 | 1257 | 1265 | 1265 |
| | Missing | 2 | 0 | 2 | 0 | 8 | 0 | 0 |

# Appendix B: Comparison of Graduation Status and Age Results

**Group Statistics**

| Graduation Status | | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Age | Not Graduated | 321 | **60.4704** | **12.44261** | 0.69448 |
| | Graduated | 942 | **63.2059** | **11.52182** | 0.37540 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| Age | Equal variances assumed | 0.987 | 0.321 | **-3.599** | **1261** | **0.000** | **-2.73554** | 0.76018 | **-4.22690** | **-1.24418** |
| | Equal variances not assumed | | | -3.465 | 519.250 | 0.001 | -2.73554 | 0.78945 | -4.28644 | -1.18464 |

# Appendix C: Comparison of Graduation Status and Sex Results

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| Sex * Graduation Status | **1263** | 99.8% | 2 | 0.2% | 1265 | 100.0% |

**Sex * Graduation Status Crosstabulation**

| | | | Graduation Status | | |
|---|---|---|---|---|---|
| | | | Not Graduated | Graduated | Total |
| Sex | Men | Count | $227_a$ | $668_a$ | 895 |
| | | Expected Count | 227.5 | 667.5 | 895.0 |
| | | % within Sex | 25.4% | 74.6% | 100.0% |
| | | % within Graduation Status | 70.7% | 70.9% | 70.9% |
| | | % of Total | 18.0% | 52.9% | 70.9% |
| | | Standardized Residual | 0.0 | 0.0 | |
| | Women | Count | $94_a$ | $274_a$ | 368 |
| | | Expected Count | 93.5 | 274.5 | 368.0 |
| | | % within Sex | 25.5% | 74.5% | 100.0% |
| | | % within Graduation Status | 29.3% | 29.1% | 29.1% |
| | | % of Total | 7.4% | 21.7% | 29.1% |
| | | Standardized Residual | 0.0 | 0.0 | |
| Total | | Count | 321 | 942 | 1263 |
| | | Expected Count | 321.0 | 942.0 | 1263.0 |
| | | % within Sex | 25.4% | 74.6% | 100.0% |
| | | % within Graduation Status | 100.0% | 100.0% | 100.0% |
| | | % of Total | 25.4% | 74.6% | 100.0% |

Each subscript letter denotes a subset of Graduation Status categories whose column proportions do not differ significantly from each other at the .05 level.

**Chi-Square Tests**

| | Value | df | Asymptotic Significance (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) | Point Probability |
|---|---|---|---|---|---|---|
| Pearson Chi-Square | **.004[a]** | **1** | 0.947 | **1.000** | 0.500 | |
| Continuity Correction[b] | 0.000 | 1 | 1.000 | | | |
| Likelihood Ratio | 0.004 | 1 | 0.947 | 1.000 | 0.500 | |
| Fisher's Exact Test | | | | 0.943 | 0.500 | |
| Linear-by-Linear Association | .004[c] | 1 | 0.947 | 1.000 | 0.500 | 0.056 |
| N of Valid Cases | 1263 | | | | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 93.53.

b. Computed only for a 2x2 table

c. The standardized statistic is -.067.

# Appendix D: Comparison of Graduation Status and Race Results

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| Race * Graduation Status | 1263 | 99.8% | 2 | 0.2% | 1265 | 100.0% |

**Race * Graduation Status Crosstabulation**

| | | | Graduation Status | | |
|---|---|---|---|---|---|
| | | | Not Graduated | Graduated | Total |
| Race | Caucasian | Count | 264[a] | 778[a] | 1042 |
| | | Expected Count | 264.8 | 777.2 | 1042.0 |
| | | % within Race | 25.3% | 74.7% | 100.0% |
| | | % within Graduation Status | 82.2% | 82.6% | 82.5% |
| | | % of Total | 20.9% | 61.6% | 82.5% |
| | | Standardized Residual | -0.1 | 0.0 | |
| | African American | Count | 23[a] | 63[a] | 86 |
| | | Expected Count | 21.9 | 64.1 | 86.0 |
| | | % within Race | 26.7% | 73.3% | 100.0% |
| | | % within Graduation Status | 7.2% | 6.7% | 6.8% |
| | | % of Total | 1.8% | 5.0% | 6.8% |
| | | Standardized Residual | 0.2 | -0.1 | |
| | Other Race | Count | 34[a] | 101[a] | 135 |
| | | Expected Count | 34.3 | 100.7 | 135.0 |
| | | % within Race | 25.2% | 74.8% | 100.0% |
| | | % within Graduation Status | 10.6% | 10.7% | 10.7% |
| | | % of Total | 2.7% | 8.0% | 10.7% |
| | | Standardized Residual | -0.1 | 0.0 | |
| Total | | Count | 321 | 942 | 1263 |
| | | Expected Count | 321.0 | 942.0 | 1263.0 |
| | | % within Race | 25.4% | 74.6% | 100.0% |
| | | % within Graduation Status | 100.0% | 100.0% | 100.0% |
| | | % of Total | 25.4% | 74.6% | 100.0% |

Each subscript letter denotes a subset of Graduation Status categories whose column proportions do not differ significantly from each other at the .05 level.

**Chi-Square Tests**

| | Value | df | Asymptotic Significance (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) | Point Probability |
|---|---|---|---|---|---|---|
| Pearson Chi-Square | **.087[a]** | **2** | 0.957 | **0.958** | | |
| Likelihood Ratio | 0.086 | 2 | 0.958 | 0.958 | | |
| Fisher's Exact Test | 0.125 | | | 0.950 | | |
| Linear-by-Linear Association | .003[b] | 1 | 0.958 | 0.960 | 0.495 | 0.040 |
| N of Valid Cases | 1263 | | | | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 21.86.

b. The standardized statistic is -.052.

# Appendix E: Comparison of Graduation Status and Education Results

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| Education * Graduation Status | **1261** | 99.7% | 4 | 0.3% | 1265 | 100.0% |

**Education * Graduation Status Crosstabulation**

| | | | Graduation Status | | |
|---|---|---|---|---|---|
| | | | Not Graduated | Graduated | Total |
| Education | University | Count | **116**$_a$ | **517**$_b$ | 633 |
| | | Expected Count | 160.6 | 472.4 | 633.0 |
| | | % within Education | 18.3% | 81.7% | 100.0% |
| | | % within Graduation Status | **36.3%** | **54.9%** | 50.2% |
| | | % of Total | 9.2% | 41.0% | 50.2% |
| | | Standardized Residual | -3.5 | 2.1 | |
| | High School or Less | Count | **68**$_a$ | **119**$_b$ | 187 |
| | | Expected Count | 47.5 | 139.5 | 187.0 |
| | | % within Education | 36.4% | 63.6% | 100.0% |
| | | % within Graduation Status | **21.3%** | **12.6%** | 14.8% |
| | | % of Total | 5.4% | 9.4% | 14.8% |
| | | Standardized Residual | 3.0 | -1.7 | |
| | College/Post-Secondary | Count | **118**$_a$ | **258**$_b$ | 376 |
| | | Expected Count | 95.4 | 280.6 | 376.0 |
| | | % within Education | 31.4% | 68.6% | 100.0% |
| | | % within Graduation Status | **36.9%** | **27.4%** | 29.8% |
| | | % of Total | 9.4% | 20.5% | 29.8% |
| | | Standardized Residual | 2.3 | -1.3 | |
| | Unknown | Count | 18$_a$ | 47$_a$ | 65 |
| | | Expected Count | 16.5 | 48.5 | 65.0 |
| | | % within Education | 27.7% | 72.3% | 100.0% |
| | | % within Graduation Status | 5.6% | 5.0% | 5.2% |
| | | % of Total | 1.4% | 3.7% | 5.2% |
| | | Standardized Residual | 0.4 | -0.2 | |
| Total | | Count | 320 | 941 | 1261 |
| | | Expected Count | 320.0 | 941.0 | 1261.0 |
| | | % within Education | 25.4% | 74.6% | 100.0% |
| | | % within Graduation Status | 100.0% | 100.0% | 100.0% |
| | | % of Total | 25.4% | 74.6% | 100.0% |

Each subscript letter denotes a subset of Graduation Status categories whose column proportions do not differ significantly from each other at the .05 level.

**Chi-Square Tests**

| | Value | df | Asymptotic Significance (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) | Point Probability |
|---|---|---|---|---|---|---|
| Pearson Chi-Square | **35.887**[a] | **3** | 0.000 | **0.000** | | |
| Likelihood Ratio | 35.869 | 3 | 0.000 | 0.000 | | |
| Fisher's Exact Test | 36.034 | | | 0.000 | | |
| Linear-by-Linear Association | 20.716[b] | 1 | 0.000 | 0.000 | 0.000 | 0.000 |
| N of Valid Cases | 1261 | | | | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 16.49.

b. The standardized statistic is -4.552.

# Appendix F: Comparison of Graduation Status and Occupation Status

# Results

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| Occupation Status * Graduation Status | **1263** | 99.8% | 2 | 0.2% | 1265 | 100.0% |

**Occupation Status * Graduation Status Crosstabulation**

| | | | Graduation Status | | |
|---|---|---|---|---|---|
| | | | Not Graduated | Graduated | Total |
| Occupation Status | Active | Count | $146_a$ | $428_a$ | 574 |
| | | Expected Count | 145.9 | 428.1 | 574.0 |
| | | % within Occupation Status | 25.4% | 74.6% | 100.0% |
| | | % within Graduation Status | 45.5% | 45.4% | 45.4% |
| | | % of Total | 11.6% | 33.9% | 45.4% |
| | | Standardized Residual | 0.0 | 0.0 | |
| | Retired | Count | **$108_a$** | **$401_b$** | 509 |
| | | Expected Count | 129.4 | 379.6 | 509.0 |
| | | % within Occupation Status | 21.2% | 78.8% | 100.0% |
| | | % within Graduation Status | **33.6%** | **42.6%** | 40.3% |
| | | % of Total | 8.6% | 31.7% | 40.3% |
| | | Standardized Residual | -1.9 | 1.1 | |
| | Unemployed | Count | $11_a$ | $29_a$ | 40 |
| | | Expected Count | 10.2 | 29.8 | 40.0 |
| | | % within Occupation Status | 27.5% | 72.5% | 100.0% |
| | | % within Graduation Status | 3.4% | 3.1% | 3.2% |
| | | % of Total | 0.9% | 2.3% | 3.2% |
| | | Standardized Residual | 0.3 | -0.2 | |
| | Medically Disabled | Count | **$37_a$** | **$46_b$** | 83 |
| | | Expected Count | 21.1 | 61.9 | 83.0 |
| | | % within Occupation Status | 44.6% | 55.4% | 100.0% |
| | | % within Graduation Status | **11.5%** | **4.9%** | 6.6% |
| | | % of Total | 2.9% | 3.6% | 6.6% |
| | | Standardized Residual | 3.5 | -2.0 | |
| | Unknown | Count | $19_a$ | $38_a$ | 57 |
| | | Expected Count | 14.5 | 42.5 | 57.0 |
| | | % within Occupation Status | 33.3% | 66.7% | 100.0% |
| | | % within Graduation Status | 5.9% | 4.0% | 4.5% |
| | | % of Total | 1.5% | 3.0% | 4.5% |
| | | Standardized Residual | 1.2 | -0.7 | |
| Total | | Count | 321 | 942 | 1263 |
| | | Expected Count | 321.0 | 942.0 | 1263.0 |
| | | % within Occupation Status | 25.4% | 74.6% | 100.0% |
| | | % within Graduation Status | 100.0% | 100.0% | 100.0% |
| | | % of Total | 25.4% | 74.6% | 100.0% |

Each subscript letter denotes a subset of Graduation Status categories whose column proportions do not differ significantly from each other at the .05 level.

**Chi-Square Tests**

| | Value | df | Asymptotic Significance (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) | Point Probability |
|---|---|---|---|---|---|---|
| Pearson Chi-Square | **22.786**[a] | **4** | 0.000 | **0.000** | | |
| Likelihood Ratio | 21.047 | 4 | 0.000 | 0.000 | | |
| Fisher's Exact Test | 21.431 | | | 0.000 | | |
| Linear-by-Linear Association | 7.320[b] | 1 | 0.007 | 0.007 | 0.004 | 0.001 |
| N of Valid Cases | 1263 | | | | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.17.

b. The standardized statistic is -2.705.

# Appendix G: Comparison of Graduation Status and Comorbidities Results

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| Comorbidities * Graduation Status | **1255** | 99.2% | 10 | 0.8% | 1265 | 100.0% |

**Comorbidities * Graduation Status Crosstabulation**

| | | | Graduation Status | | |
|---|---|---|---|---|---|
| | | | Not Graduated | Graduated | Total |
| Comorbidities | >2 Comorbidities | Count | **$121_a$** | **$278_b$** | 399 |
| | | Expected Count | 101.1 | 297.9 | 399.0 |
| | | % within Comorbidities | 30.3% | 69.7% | 100.0% |
| | | % within Graduation Status | **38.1%** | **29.7%** | 31.8% |
| | | % of Total | 9.6% | 22.2% | 31.8% |
| | | Standardized Residual | 2.0 | -1.2 | |
| | No Comorbidity | Count | $49_a$ | $172_a$ | 221 |
| | | Expected Count | 56.0 | 165.0 | 221.0 |
| | | % within Comorbidities | 22.2% | 77.8% | 100.0% |
| | | % within Graduation Status | 15.4% | 18.4% | 17.6% |
| | | % of Total | 3.9% | 13.7% | 17.6% |
| | | Standardized Residual | -0.9 | 0.5 | |
| | 1 Comorbidity | Count | $62_a$ | $225_a$ | 287 |
| | | Expected Count | 72.7 | 214.3 | 287.0 |
| | | % within Comorbidities | 21.6% | 78.4% | 100.0% |
| | | % within Graduation Status | 19.5% | 24.0% | 22.9% |
| | | % of Total | 4.9% | 17.9% | 22.9% |
| | | Standardized Residual | -1.3 | 0.7 | |
| | 2 Comorbidities | Count | $86_a$ | $262_a$ | 348 |
| | | Expected Count | 88.2 | 259.8 | 348.0 |
| | | % within Comorbidities | 24.7% | 75.3% | 100.0% |
| | | % within Graduation Status | 27.0% | 28.0% | 27.7% |
| | | % of Total | 6.9% | 20.9% | 27.7% |
| | | Standardized Residual | -0.2 | 0.1 | |
| Total | | Count | 318 | 937 | 1255 |
| | | Expected Count | 318.0 | 937.0 | 1255.0 |
| | | % within Comorbidities | 25.3% | 74.7% | 100.0% |
| | | % within Graduation Status | 100.0% | 100.0% | 100.0% |
| | | % of Total | 25.3% | 74.7% | 100.0% |

Each subscript letter denotes a subset of Graduation Status categories whose column proportions do not differ significantly from each other at the .05 level.

**Chi-Square Tests**

| | Value | df | Asymptotic Significance (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) | Point Probability |
|---|---|---|---|---|---|---|
| Pearson Chi-Square | **8.607**[a] | **3** | 0.035 | **0.035** | | |
| Likelihood Ratio | 8.513 | 3 | 0.037 | 0.037 | | |
| Fisher's Exact Test | 8.414 | | | 0.038 | | |
| Linear-by-Linear Association | 3.578[b] | 1 | 0.059 | 0.062 | 0.031 | 0.004 |
| N of Valid Cases | 1255 | | | | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 56.00.

b. The standardized statistic is 1.891.

# Appendix H: Comparison of Graduation Status and Referral Indication Results

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| Referral Indication * Graduation Status | **1263** | 99.8% | 2 | 0.2% | 1265 | 100.0% |

**Chi-Square Tests**

| | Value | df | Asymptotic Significance (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) | Point Probability |
|---|---|---|---|---|---|---|
| Pearson Chi-Square | **6.865**[a] | **9** | **0.651** | .[b] | | |
| Likelihood Ratio | 6.867 | 9 | 0.651 | .[b] | | |
| Fisher's Exact Test | .[b] | | | .[b] | | |
| Linear-by-Linear Association | .201[c] | 1 | 0.654 | 0.660 | 0.333 | 0.008 |
| N of Valid Cases | 1263 | | | | | |

a. 2 cells (10.0%) have expected count less than 5. The minimum expected count is 1.27.

b. Cannot be computed because there is insufficient memory.

c. The standardized statistic is .448.

**Referral Indication * Graduation Status Crosstabulation**

| | | | Graduation Status | | |
|---|---|---|---|---|---|
| | | | Not Graduated | Graduated | Total |
| Referral Indication | MI | Count | 70[a] | 201[a] | 271 |
| | | Expected Count | 68.9 | 202.1 | 271.0 |
| | | % within Referral Indication | 25.8% | 74.2% | 100.0% |
| | | % within Graduation Status | 21.8% | 21.3% | 21.5% |
| | | % of Total | 5.5% | 15.9% | 21.5% |
| | | Standardized Residual | 0.1 | -0.1 | |
| | PCI/Stent | Count | 89[a] | 222[a] | 311 |
| | | Expected Count | 79.0 | 232.0 | 311.0 |
| | | % within Referral Indication | 28.6% | 71.4% | 100.0% |
| | | % within Graduation Status | 27.7% | 23.6% | 24.6% |
| | | % of Total | 7.0% | 17.6% | 24.6% |
| | | Standardized Residual | 1.1 | -0.7 | |
| | CABG | Count | 38[a] | 147[a] | 185 |
| | | Expected Count | 47.0 | 138.0 | 185.0 |
| | | % within Referral Indication | 20.5% | 79.5% | 100.0% |
| | | % within Graduation Status | 11.8% | 15.6% | 14.6% |
| | | % of Total | 3.0% | 11.6% | 14.6% |
| | | Standardized Residual | -1.3 | 0.8 | |
| | Valve Replacement/Repair | Count | 50[a] | 157[a] | 207 |
| | | Expected Count | 52.6 | 154.4 | 207.0 |
| | | % within Referral Indication | 24.2% | 75.8% | 100.0% |
| | | % within Graduation Status | 15.6% | 16.7% | 16.4% |
| | | % of Total | 4.0% | 12.4% | 16.4% |
| | | Standardized Residual | -0.4 | 0.2 | |
| | Heart Transplant | Count | 1[a] | 4[a] | 5 |
| | | Expected Count | 1.3 | 3.7 | 5.0 |
| | | % within Referral Indication | 20.0% | 80.0% | 100.0% |
| | | % within Graduation Status | 0.3% | 0.4% | 0.4% |
| | | % of Total | 0.1% | 0.3% | 0.4% |
| | | Standardized Residual | -0.2 | 0.1 | |
| | Stable Angina | Count | 8[a] | 18[a] | 26 |
| | | Expected Count | 6.6 | 19.4 | 26.0 |
| | | % within Referral Indication | 30.8% | 69.2% | 100.0% |
| | | % within Graduation Status | 2.5% | 1.9% | 2.1% |
| | | % of Total | 0.6% | 1.4% | 2.1% |
| | | Standardized Residual | 0.5 | -0.3 | |
| | Other | Count | 8[a] | 15[a] | 23 |
| | | Expected Count | 5.8 | 17.2 | 23.0 |
| | | % within Referral Indication | 34.8% | 65.2% | 100.0% |
| | | % within Graduation Status | 2.5% | 1.6% | 1.8% |
| | | % of Total | 0.6% | 1.2% | 1.8% |
| | | Standardized Residual | 0.9 | -0.5 | |
| | Heart Failure | Count | 14[a] | 36[a] | 50 |
| | | Expected Count | 12.7 | 37.3 | 50.0 |
| | | % within Referral Indication | 28.0% | 72.0% | 100.0% |
| | | % within Graduation Status | 4.4% | 3.8% | 4.0% |
| | | % of Total | 1.1% | 2.9% | 4.0% |
| | | Standardized Residual | 0.4 | -0.2 | |
| | MI/PCI | Count | 35[a] | 122[a] | 157 |
| | | Expected Count | 39.9 | 117.1 | 157.0 |
| | | % within Referral Indication | 22.3% | 77.7% | 100.0% |
| | | % within Graduation Status | 10.9% | 13.0% | 12.4% |
| | | % of Total | 2.8% | 9.7% | 12.4% |
| | | Standardized Residual | -0.8 | 0.5 | |
| | CABG/Valve Replacement/Repair | Count | 8[a] | 20[a] | 28 |
| | | Expected Count | 7.1 | 20.9 | 28.0 |
| | | % within Referral Indication | 28.6% | 71.4% | 100.0% |
| | | % within Graduation Status | 2.5% | 2.1% | 2.2% |
| | | % of Total | 0.6% | 1.6% | 2.2% |
| | | Standardized Residual | 0.3 | -0.2 | |
| Total | | Count | 321 | 942 | 1263 |
| | | Expected Count | 321.0 | 942.0 | 1263.0 |
| | | % within Referral Indication | 25.4% | 74.6% | 100.0% |
| | | % within Graduation Status | 100.0% | 100.0% | 100.0% |
| | | % of Total | 25.4% | 74.6% | 100.0% |

Each subscript letter denotes a subset of Graduation Status categories whose column proportions do not differ significantly from each other at the .05 level.

# Appendix I: Comparison of Age and Occupation Status Results

**Descriptives**

| Age | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | |
| Active | **574** | **56.6498** | **10.18199** | 0.42499 | 55.8151 | 57.4846 | 21.00 | 91.00 |
| Retired | **510** | **71.0118** | **8.36659** | 0.37048 | 70.2839 | 71.7396 | 47.00 | 95.00 |
| Unemployed | **40** | **56.5500** | **7.74580** | 1.22472 | 54.0728 | 59.0272 | 40.00 | 79.00 |
| Medically Disabled | **84** | **53.7738** | **9.36071** | 1.02134 | 51.7424 | 55.8052 | 21.00 | 72.00 |
| Unknown | **57** | **62.4561** | **11.34849** | 1.50314 | 59.4450 | 65.4673 | 37.00 | 87.00 |
| Total | **1265** | **62.5075** | **11.80894** | 0.33202 | 61.8561 | 63.1589 | 21.00 | 95.00 |

**Test of Homogeneity of Variances**

| | | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| Age | Based on Mean | 4.315 | 4 | 1260 | **0.002** |
| | Based on Median | 4.156 | 4 | 1260 | 0.002 |
| | Based on Median and with adjusted df | 4.156 | 4 | 1198.310 | 0.002 |
| | Based on trimmed mean | 4.228 | 4 | 1260 | 0.002 |

**Robust Tests of Equality of Means**

| Age | Statistic[a] | df1 | df2 | Sig. |
|---|---|---|---|---|
| Welch | **195.932** | **4** | **153.978** | **0.000** |

a. Asymptotically F distributed.

**Multiple Comparisons**

Dependent Variable: Age

| (I) Occupation Status | | | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| Tukey HSD | Active | Retired | -14.36194* | 0.57336 | 0.000 | -15.9282 | -12.7957 |
| | | Unemployed | 0.09983 | 1.54081 | 1.000 | -4.1093 | 4.3089 |
| | | Medically Disabled | 2.87602 | 1.10070 | 0.069 | -0.1308 | 5.8828 |
| | | Unknown | -5.80631* | 1.30849 | 0.000 | -9.3808 | -2.2319 |
| | Retired | Active | 14.36194* | 0.57336 | 0.000 | 12.7957 | 15.9282 |
| | | Unemployed | 14.46176* | 1.54710 | 0.000 | 10.2355 | 18.6880 |
| | | Medically Disabled | 17.23796* | 1.10948 | 0.000 | 14.2072 | 20.2688 |
| | | Unknown | 8.55562* | 1.31589 | 0.000 | 4.9610 | 12.1503 |
| | Unemployed | Active | -0.09983 | 1.54081 | 1.000 | -4.3089 | 4.1093 |
| | | Retired | -14.46176* | 1.54710 | 0.000 | -18.6880 | -10.2355 |
| | | Medically Disabled | 2.77619 | 1.81006 | 0.541 | -2.1684 | 7.7208 |
| | | Unknown | -5.90614* | 1.94343 | 0.020 | -11.2151 | -0.5972 |
| | Medically Disabled | Active | -2.87602 | 1.10070 | 0.069 | -5.8828 | 0.1308 |
| | | Retired | -17.23796* | 1.10948 | 0.000 | -20.2688 | -14.2072 |
| | | Unemployed | -2.77619 | 1.81006 | 0.541 | -7.7208 | 2.1684 |
| | | Unknown | -8.68233* | 1.61690 | 0.000 | -13.0993 | -4.2654 |
| | Unknown | Active | 5.80631* | 1.30849 | 0.000 | 2.2319 | 9.3808 |
| | | Retired | -8.55562* | 1.31589 | 0.000 | -12.1503 | -4.9610 |
| | | Unemployed | 5.90614* | 1.94343 | 0.020 | 0.5972 | 11.2151 |
| | | Medically Disabled | 8.68233* | 1.61690 | 0.000 | 4.2654 | 13.0993 |
| Games-Howell | Active | Retired | **-14.36194*** | 0.56380 | **0.000** | **-15.9025** | **-12.8214** |
| | | Unemployed | 0.09983 | 1.29636 | 1.000 | -3.5716 | 3.7713 |
| | | Medically Disabled | 2.87602 | 1.10623 | 0.077 | -0.1905 | 5.9425 |
| | | Unknown | -5.80631* | 1.56207 | 0.004 | -10.1887 | -1.4239 |
| | Retired | Active | 14.36194* | 0.56380 | 0.000 | 12.8214 | 15.9025 |
| | | Unemployed | 14.46176* | 1.27953 | 0.000 | 10.8307 | 18.0929 |
| | | Medically Disabled | 17.23796* | 1.08646 | 0.000 | 14.2227 | 20.2532 |
| | | Unknown | 8.55562* | 1.54813 | 0.000 | 4.2079 | 12.9033 |
| | Unemployed | Active | -0.09983 | 1.29636 | 1.000 | -3.7713 | 3.5716 |
| | | Retired | **-14.46176*** | 1.27953 | **0.000** | **-18.0929** | **-10.8307** |
| | | Medically Disabled | 2.77619 | 1.59470 | 0.414 | -1.6619 | 7.2143 |
| | | Unknown | -5.90614* | 1.93891 | 0.024 | -11.2980 | -0.5142 |
| | Medically Disabled | Active | -2.87602 | 1.10623 | 0.077 | -5.9425 | 0.1905 |
| | | Retired | **-17.23796*** | 1.08646 | **0.000** | **-20.2532** | **-14.2227** |
| | | Unemployed | -2.77619 | 1.59470 | 0.414 | -7.2143 | 1.6619 |
| | | Unknown | -8.68233* | 1.81730 | 0.000 | -13.7270 | -3.6376 |
| | Unknown | Active | 5.80631* | 1.56207 | 0.004 | 1.4239 | 10.1887 |
| | | Retired | **-8.55562*** | 1.54813 | **0.000** | **-12.9033** | **-4.2079** |
| | | Unemployed | 5.90614* | 1.93891 | 0.024 | 0.5142 | 11.2980 |
| | | Medically Disabled | 8.68233* | 1.81730 | 0.000 | 3.6376 | 13.7270 |

*. The mean difference is significant at the 0.05 level.

# Appendix J: Comparison of Age and Prevalence of Comorbidities Results

**Descriptives**

Age

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | |
| >2 Comorbidities | **399** | **64.2757** | **10.76212** | 0.53878 | 63.2165 | 65.3349 | 21.00 | 95.00 |
| No Comorbidity | **221** | **59.4299** | **12.32074** | 0.82878 | 57.7965 | 61.0632 | 23.00 | 91.00 |
| 1 Comorbidity | **287** | **61.8293** | **12.51805** | 0.73892 | 60.3749 | 63.2837 | 23.00 | 92.00 |
| 2 Comorbidities | **350** | **63.0000** | **11.64691** | 0.62255 | 61.7756 | 64.2244 | 21.00 | 92.00 |
| Total | **1257** | **62.5099** | **11.81095** | 0.33313 | 61.8564 | 63.1635 | 21.00 | 95.00 |

**Test of Homogeneity of Variances**

| | | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| Age | Based on Mean | 2.403 | 3 | 1253 | **0.066** |
| | Based on Median | 2.398 | 3 | 1253 | 0.067 |
| | Based on Median and with adjusted df | 2.398 | 3 | 1236.336 | 0.067 |
| | Based on trimmed mean | 2.384 | 3 | 1253 | 0.068 |

**ANOVA**

Age

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 3557.654 | **3** | 1185.885 | **8.657** | **0.000** |
| Within Groups | 171652.471 | **1253** | 136.993 | | |
| Total | 175210.126 | 1256 | | | |

**Multiple Comparisons**

Dependent Variable: Age

| (I) Comorbidities | | | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| Tukey HSD | >2 Comorbidities | No Comorbidity | **4.84582*** | 0.98144 | **0.000** | **2.3211** | **7.3706** |
| | | 1 Comorbidity | **2.44642*** | 0.90591 | **0.035** | **0.1160** | **4.7769** |
| | | 2 Comorbidities | 1.27569 | 0.85718 | 0.445 | -0.9294 | 3.4808 |
| | No Comorbidity | >2 Comorbidities | -4.84582* | 0.98144 | 0.000 | -7.3706 | -2.3211 |
| | | 1 Comorbidity | -2.39940 | 1.04748 | 0.101 | -5.0940 | 0.2952 |
| | | 2 Comorbidities | -3.57014* | 1.00563 | 0.002 | -6.1571 | -0.9832 |
| | 1 Comorbidity | >2 Comorbidities | -2.44642* | 0.90591 | 0.035 | -4.7769 | -0.1160 |
| | | No Comorbidity | 2.39940 | 1.04748 | 0.101 | -0.2952 | 5.0940 |
| | | 2 Comorbidities | -1.17073 | 0.93206 | 0.591 | -3.5684 | 1.2270 |
| | 2 Comorbidities | >2 Comorbidities | -1.27569 | 0.85718 | 0.445 | -3.4808 | 0.9294 |
| | | No Comorbidity | **3.57014*** | 1.00563 | **0.002** | **0.9832** | **6.1571** |
| | | 1 Comorbidity | 1.17073 | 0.93206 | 0.591 | -1.2270 | 3.5684 |
| Games-Howell | >2 Comorbidities | No Comorbidity | 4.84582* | 0.98852 | 0.000 | 2.2957 | 7.3959 |
| | | 1 Comorbidity | 2.44642* | 0.91448 | 0.038 | 0.0900 | 4.8029 |
| | | 2 Comorbidities | 1.27569 | 0.82332 | 0.409 | -0.8444 | 3.3958 |
| | No Comorbidity | >2 Comorbidities | -4.84582* | 0.98852 | 0.000 | -7.3959 | -2.2957 |
| | | 1 Comorbidity | -2.39940 | 1.11035 | 0.136 | -5.2620 | 0.4632 |
| | | 2 Comorbidities | -3.57014* | 1.03656 | 0.003 | -6.2431 | -0.8972 |
| | 1 Comorbidity | >2 Comorbidities | -2.44642* | 0.91448 | 0.038 | -4.8029 | -0.0900 |
| | | No Comorbidity | 2.39940 | 1.11035 | 0.136 | -0.4632 | 5.2620 |
| | | 2 Comorbidities | -1.17073 | 0.96621 | 0.620 | -3.6600 | 1.3186 |
| | 2 Comorbidities | >2 Comorbidities | -1.27569 | 0.82332 | 0.409 | -3.3958 | 0.8444 |
| | | No Comorbidity | 3.57014* | 1.03656 | 0.003 | 0.8972 | 6.2431 |
| | | 1 Comorbidity | 1.17073 | 0.96621 | 0.620 | -1.3186 | 3.6600 |

*. The mean difference is significant at the 0.05 level.

## Appendix K: Logistic Regression Model for Graduation Status Results

### Case Processing Summary

| Unweighted Cases[a] | | N | Percent |
|---|---|---|---|
| Selected Cases | Included in Analysis | **1253** | 99.1 |
| | Missing Cases | 12 | 0.9 |
| | Total | 1265 | 100.0 |
| Unselected Cases | | 0 | 0.0 |
| Total | | 1265 | 100.0 |

a. If weight is in effect, see classification table for the total number of cases.

**Dependent Variable Encoding**

| Original Value | Internal Value |
|---|---|
| Not Graduated | 0 |
| Graduated | 1 |

**Categorical Variables Codings**

| | | | Parameter coding | | | |
|---|---|---|---|---|---|---|
| | | Frequency | (1) | (2) | (3) | (4) |
| Occupation Status | Active | 569 | 0.000 | 0.000 | 0.000 | 0.000 |
| | Retired | 508 | 1.000 | 0.000 | 0.000 | 0.000 |
| | Unemployed | 40 | 0.000 | 1.000 | 0.000 | 0.000 |
| | Medically Disabled | 83 | 0.000 | 0.000 | 1.000 | 0.000 |
| | Unknown | 53 | 0.000 | 0.000 | 0.000 | 1.000 |
| Comorbidities | >2 Comorbidities | 398 | 0.000 | 0.000 | 0.000 | |
| | No Comorbidity | 220 | 1.000 | 0.000 | 0.000 | |
| | 1 Comorbidity | 287 | 0.000 | 1.000 | 0.000 | |
| | 2 Comorbidities | 348 | 0.000 | 0.000 | 1.000 | |
| Education | University | 630 | 0.000 | 0.000 | 0.000 | |
| | High School or Less | 187 | 1.000 | 0.000 | 0.000 | |
| | College/Post-Secondary | 375 | 0.000 | 1.000 | 0.000 | |
| | Unknown | 61 | 0.000 | 0.000 | 1.000 | |
| Race | Caucasian | 1032 | 0.000 | 0.000 | | |
| | African American | 86 | 1.000 | 0.000 | | |
| | Other Race | 135 | 0.000 | 1.000 | | |
| Sex | Men | 887 | 0.000 | | | |
| | Women | 366 | 1.000 | | | |

### Block 1: Method = Enter

**Omnibus Tests of Model Coefficients**

| | | Chi-square | df | Sig. |
|---|---|---|---|---|
| Step 1 | Step | 63.022 | 14 | 0.000 |
| | Block | 63.022 | 14 | 0.000 |
| | Model | **63.022** | **14** | **0.000** |

**Model Summary**

| Step | -2 Log likelihood | Cox & Snell R Square | Nagelkerke R Square |
|---|---|---|---|
| 1 | 1354.370[a] | 0.049 | **0.072** |

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

**Classification Table[a]**

| Observed | | | Predicted | | |
|---|---|---|---|---|---|
| | | | Graduation Status | | |
| | | | Not Graduated | Graduated | Percentage Correct |
| Step 1 | Graduation Status | Not Graduated | 17 | 300 | 5.4 |
| | | Graduated | 12 | 924 | 98.7 |
| | Overall Percentage | | | | **75.1** |

a. The cut value is .500

**Variables in the Equation**

| | | B | S.E. | Wald | df | Sig. | Exp(B) | 95% C.I.for EXP(B) Lower | 95% C.I.for EXP(B) Upper |
|---|---|---|---|---|---|---|---|---|---|
| Step 1[a] | Age | 0.016 | 0.007 | 4.878 | 1 | **0.027** | **1.016** | **1.002** | **1.030** |
| | Sex(1) | 0.128 | 0.150 | 0.725 | 1 | 0.395 | 1.136 | 0.847 | 1.525 |
| | Occupation Status | | | 7.634 | 4 | 0.106 | | | |
| | Occupation Status(1) | 0.166 | 0.184 | 0.816 | 1 | 0.366 | 1.181 | 0.823 | 1.693 |
| | Occupation Status(2) | 0.192 | 0.380 | 0.254 | 1 | 0.614 | 1.211 | 0.575 | 2.553 |
| | Occupation Status(3) | -0.539 | 0.259 | 4.333 | 1 | 0.037 | 0.583 | 0.351 | 0.969 |
| | Occupation Status(4) | -0.303 | 0.333 | 0.827 | 1 | 0.363 | 0.739 | 0.384 | 1.419 |
| | Comorbidities | | | 7.165 | 3 | 0.067 | | | |
| | Comorbidities(1) | 0.407 | 0.207 | 3.874 | 1 | 0.049 | 1.502 | 1.002 | 2.253 |
| | Comorbidities(2) | 0.440 | 0.187 | 5.526 | 1 | 0.019 | 1.553 | 1.076 | 2.241 |
| | Comorbidities(3) | 0.287 | 0.172 | 2.788 | 1 | 0.095 | 1.332 | 0.951 | 1.866 |
| | Education | | | 25.089 | 3 | **0.000** | | | |
| | Education(1) | -0.832 | 0.195 | 18.279 | 1 | **0.000** | **0.435** | **0.297** | **0.637** |
| | Education(2) | -0.658 | 0.159 | 17.223 | 1 | **0.000** | **0.518** | **0.380** | **0.707** |
| | Education(3) | -0.446 | 0.330 | 1.830 | 1 | 0.176 | 0.640 | 0.335 | 1.222 |
| | Race | | | 1.094 | 2 | 0.579 | | | |
| | Race(1) | 0.277 | 0.269 | 1.063 | 1 | 0.303 | 1.319 | 0.779 | 2.234 |
| | Race(2) | -0.018 | 0.219 | 0.007 | 1 | 0.935 | 0.982 | 0.640 | 1.508 |
| | Constant | 0.171 | 0.442 | 0.150 | 1 | 0.699 | 1.187 | | |

a. Variable(s) entered on step 1: Age, Sex, Occupation Status, Comorbidities, Education, Race.

## Vita Auctoris

| | |
|---|---|
| NAME: | Cayla Wood |
| PLACE OF BIRTH: | Windsor, Ontario |
| YEAR OF BIRTH: | 1995 |
| EDUCATION: | Harrow District High School, Harrow, ON, 2013 |
| | University of Windsor, B.H.K., Windsor, ON, 2017 |
| | University of Windsor, M.H.K., Windsor, ON, 2019 |